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THE NEED FOR REGULATIONS TO ADDRESS THE SLOW TRANSITION TO HALON ALTERNATIVES IN THE CIVIL AVIATION INDUSTRY

BAILEY PHAM*

IN THE MID-1970s, scientists discovered that some man-made chemicals were destroying the ozone layer, which resulted in an increase in ultraviolet radiation exposure. In response to this discovery, many countries decided to address this global threat, culminating in the 1987 Montreal Protocol on Substances that Deplete the Ozone Layer.1 The participating countries made commitments to eliminate production of ozone-depleting substances by certain deadlines.2 One category of these substances is halons, the production of which the Montreal Protocol required to cease by 1994.3

Before 1994, halons, especially Halon 1301 and Halon 1211, were used extensively as effective gaseous fire-suppression agents.4 After production ceased, many industries found substitutes and halon alternatives; however, the civil aviation industry has not been successful in implementing halon alternatives.5 Old and new aircraft still rely on halons as fire-suppression agents.6

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2 See generally Montreal Protocol, supra note 1.
3 Id. art. 2B.
5 Id. at 7.
6 Id.
Civil aircrafts have four applications that use halon for fire suppression: lavatory trash receptacle extinguishers, handheld extinguishers, cargo compartment extinguishers, and engine nacelle and auxiliary power unit protection systems. Of these four applications, halon alternatives have been identified for all applications except for the engine nacelle and auxiliary power unit protection systems. Nonetheless, only one alternative has been installed on one type of aircraft for the lavatory trash receptacle extinguisher. This may soon become a problem for the aviation industry as the halon stockpile decreases and no alternatives have been identified and installed in the aircraft.

This Comment will discuss the status of identifying halon alternatives in the civil aircraft applications and the technical, economic, and regulatory issues involved with implementing these alternatives for each of the four applications. The various technical, economic, and regulatory barriers will be compared to determine which of the barriers serve as the greatest impediment to the civil aviation industry. Furthermore, this paper will discuss the courses of action recommended by the United Nations Environment Programme (UNEP) and the International Civil Aviation Organization (ICAO), and evaluate whether the airlines will be able to comply with the recommended courses of action.

I. WHAT CAUSED THE PROBLEM?: PROTECTING THE ENVIRONMENT AND THE MONTREAL PROTOCOL ON SUBSTANCES THAT DEPLETE THE OZONE LAYER

A stratospheric layer of ozone protects the ecosystem from harmful rays of ultraviolet radiation from the sun. However, this layer is in danger due to society's activities and the man-made chemicals people introduce into the atmosphere. These chemicals are interacting with the ozone to create a hole in this layer, harming the environment. In response to this hole, some

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7 Id.
9 Catchpole et al., supra note 4, at 7.
10 Id.
11 Id. at 8.
12 See infra text accompanying note 37.
countries entered into an international agreement to formulate provisions to identify both the causes of the ozone hole and a plan to eliminate them. One of the causes identified was the use of halons in multiple industries.

A. The Ozone Hole

Ozone, which consists of three oxygen atoms, is a "highly reactive form of oxygen [and] is found in trace quantities both in the natural stratosphere (15-50 km altitude) and in polluted surface air." "Ozone is created when short-wave ultraviolet radiation splits an ordinary two-atom oxygen molecule [and] the chemically active single atoms attach themselves to ordinary oxygen molecules to form three-atom molecules of ozone." Ozone is a powerful oxidizing agent that, while explosive and toxic in high concentrations, is only a minimal threat to human beings.

The effects of ozone are dependent on its location. Ozone may be harmful or protective depending on where the ozone exists. If the ozone is located in the stratosphere (approximately 25-40 km above the Earth's surface) then the ozone acts as a shield to block out the sun's harmful ultraviolet rays. This shield helps protect individuals from skin cancer, cataracts, and impaired immune systems. However, the closer the ozone is to the Earth's surface, the more it acts as a toxic pollutant that damages plants and lung tissue. The ozone located at surface level is a major component of smog and is destructive to one's health.

Basically, there are two types of ozone. One type of ozone serves as a gaseous shield in the stratosphere, while the second type is a destructive, toxic molecule that exists closer to the

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13 See infra text accompanying notes 38-37.
14 See infra text accompanying note 37.
17 Id.
19 Id. at 14-15.
21 Nilsson, supra note 18, at 21.
22 Id.
Earth's surface. "The total concentration of ozone in the atmosphere depends on the balance between the reactions that create ozone and the ones that destroy it." It is important to maintain a proper balance in these processes; therefore, scientists have conducted studies on these processes to determine what creates and destroys ozone.

For example, in the 1950s, a research group from The British Antarctic Survey began to study the Polar Stratospheric Clouds over Antarctica. As a result of these studies, three of the scientists from the research group, Joseph Farman, Brian Gardiner, and Jonathan Shanklin, discovered the Antarctic ozone hole. Their findings "revealed that between 1980 and 1984, the ozone present over Antarctica, on both an all-seasons basis, but most spectacularly, in spring, was thinning by up to 50 percent." These findings were first reported in 1984 and published in Nature in May of 1985.

Over the years, the ozone hole has become more of a concern as it has rapidly increased. In 2001, scientists reported that the hole "was over three times the size of continental Europe." The ozone hole is also of concern because it is not restricted to Antarctica. The hole forms over Antarctica each October and then rotates after eight weeks, passing "over more populated areas, including [t]he Falkland Islands, South Georgia and the tip of South America." This hole allows harmful, high-energy radiation into the Earth's ecosystem, which is known to cause skin cancer, create cataracts, harm one's immune system, and upset the fragile balance of an entire ecosystem.

B. THE MONTREAL PROTOCOL ON SUBSTANCES THAT DEPLETE THE OZONE LAYER

In response to the discovery of the hole in the ozone layer, the member states of the UNEP agreed to the Vienna Conven-
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Through the Convention, the member nations established mechanisms for international cooperation in researching the ozone layer, the effects of ozone-depleting chemicals (ODCs), and the identification of alternative substances and technologies.\(^\text{34}\) This international cooperative effort led to the creation of the Montreal Protocol on Substances that Deplete the Ozone Layer, which was negotiated and signed by twenty-four countries and the European Economic Community on September 16, 1987, at the Montreal headquarters of the ICAO.\(^\text{35}\)

The Montreal Protocol, which became effective in 1989, "contains provisions for regular review of the adequacy of control measures that are based on assessments of evolving scientific, environmental, technical, and economic information."\(^\text{36}\) Based on the scientific findings discussed at the Vienna Convention regarding evidence that certain elements were depleting the stratospheric ozone layer, the Montreal Protocol established deadlines for the phase-out of production and consumption of controlled (ozone-depleting) substances, which include chlorofluorocarbons (CFCs), halons, and hydro chlorofluorocarbons (HCFCs).\(^\text{37}\) To achieve this phase-out, the agreement provides trade sanctions for countries that do not comply with the deadlines, as well as incentives for non-signing countries to sign the agreement.\(^\text{38}\) The purpose of these sanctions and incentives is to stress the importance of addressing the problem on a global level and to identify less harmful alternatives.\(^\text{39}\) To date, over 180 countries have signed the agreement, recognizing the necessity of a global effort to protect the environment from such harmful substances.\(^\text{40}\)

The parties amended the provisions of the Montreal Protocol five times at meetings in London (1990), Copenhagen (1992),


\(^{34}\) 1985 Vienna Convention, supra note 33.


\(^{37}\) Catchpole et al., supra note 4, at 6; Alternative Fluorocarbons, supra note 36.

\(^{38}\) Montreal Protocol, supra note 1, art. 4–4a.

\(^{39}\) PARSON, supra note 35, at 129–30, 137; Catchpole et al., supra note 4, at 6.

\(^{40}\) Catchpole et al., supra note 4, at 6.
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Vienna (1995), Montreal (1997), and Beijing (1999). For the most part, these amendments accelerated the phase-out schedules of the controlled substances. As for halons, the current provisions of the Montreal Protocol required developed countries to phase out the production of halons by January 1, 1994, and developing countries to phase out by January 1, 2010. Although the parties to the Montreal Protocol accelerated the phase-out schedules, other regulatory bodies, such as the European Union (formerly known as the European Community) and the U.S. Environmental Protection Agency (EPA), have implemented even stricter regulations and phase-out schedules.

In compliance with the Montreal Protocol, the U.S. government implemented the Clean Air Act to prohibit the production and import of virgin halons 1211, 1301, and 2402 beginning January 1, 1994. Under section 602 of the Clean Air Act, the EPA classifies ozone-depleting chemicals as class I and class II substances. Class I substances, which include halons, are chemicals with ozone-depletion potential of 0.2 or greater. The EPA also issued a final rule on March 5, 1998 barring the production of a halon blend with two or more of the prohibited halons. The EPA did, however, allow an exception for halon blends formulated using recycled halons solely for the purpose of aviation fire protection, provided that blends pro-

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41 Montreal Protocol, supra note 1, i; Gillespie, supra note 20, at 243.
42 Montreal Protocol, supra note 1, art. 2-21; Alternative Fluorocarbons, supra note 36.
43 Montreal Protocol, supra note 1, art. 2B.
44 Alternative Fluorocarbons, supra note 36.
48 Id.
duced under this exemption are recycled to meet the relevant purity standards for each individual halon. After these rules, the only sources of halon in the United States are recycled halon and inventories produced before January 1, 1994.

C. ONE OF THE CAUSES OF THE OZONE HOLE: HALONS

The increase in the size of the hole in the ozone layer is due to ozone-depleting chemicals that contain certain trace elements of nitrogen, hydrogen, bromine, and chlorine. The ozone-depleting chemicals that contain these trace elements include CFCs, halons, carbon tetrachloride, methyl chloroform, HCFCs, hydrobromofluorocarbons (HBFCs), and methyl bromide. Besides CFCs, halons cause the most destruction to the stratospheric ozone layer.

"Halons are gaseous or easily vaporized halocarbons used primarily for putting out fires, but also for explosion protection." In the United States, the three types of halons used most often are Halon 1211, which is mainly used in streaming applications, Halon 1301, which is mainly used in total flooding applications, and Halon 2402, which serves as "an extinguishant in engine nacelles (the streamlined enclosure surrounding the engine)." Streaming applications are also known as local applications. These applications, which are often manually operated, consist of systems that apply the fire suppression agent directly onto a fire or into the area of a fire. Conversely, total flooding applications "apply an extinguishing agent to an enclosed space in order to achieve a concentration of the agent."

51 Id. at 11,086.
52 GILLESPIE, supra note 20, at 4.
53 See id. at 19–30.
56 Id.; Catchpole et al., supra note 4, at 7.
58 Id. at 6.
59 Id. at 6.
Halons possess several characteristics that make them popular for use as fire protectants.\(^{60}\) First, halons “are highly effective against solid, liquid/gaseous, and electrical fires.”\(^{61}\) Second, halons usually do not cause secondary damage because they disperse quickly and do not leave a residue on the property being protected.\(^{62}\) Third, halons “require relatively simple design and installation.”\(^{63}\) Fourth, halons do not conduct electricity and are effective over broad temperature ranges, so they are effective at extinguishing fires around electrical equipment.\(^{64}\) Finally, “halons are generally safe for limited human exposure when used with proper exposure controls.”\(^{65}\) Depending on the location of the fire, all of these characteristics make halons attractive for use as a fire suppressant for the aviation industry.

Although there are advantages to using halons for fire and explosion protection, there are also disadvantages to using halons due to their effects on the ozone. Halons contain bromine, which reacts more strongly with ozone than the chlorine found in CFCs, the most commonly known ozone-depleting chemicals.\(^{66}\) For example, in 1986, halons represented twenty-three percent of the ozone destruction associated with class I of the ozone-depleting chemicals, even though halon production at the time consisted of only two percent of production of all class I substances.\(^{67}\) Before the early 1990s, testing and training, service and repair, and accidental discharges released more halons into the air than actually extinguishing fires.\(^{68}\) Through the Montreal Protocol’s technology assessment, the Halons Technical Options Committee (HTOC) discovered that “only 15 percent of annual Halon 1211 emissions and 18 percent of annual Halon 1301 emissions occur as a result of use to extinguish

\(^{60}\) Protection of Stratospheric Ozone, 63 Fed. Reg. at 11,085; HUGHES ASSOCS. & ICF CONSULTING, \textit{supra} note 54, at 5.


\(^{62}\) \textit{Id.}; HUGHES ASSOCS. & ICF CONSULTING, \textit{supra} note 54, at 5.

\(^{63}\) HUGHES ASSOCS. & ICF CONSULTING, \textit{supra} note 54, at 5.

\(^{64}\) Protection of Stratospheric Ozone, 63 Fed. Reg. at 11,085.

\(^{65}\) \textit{Id.}

\(^{66}\) GILLESPIE, \textit{supra} note 20, at 24; HUGHES ASSOCS. & ICF CONSULTING, \textit{supra} note 54, at 5.


\(^{68}\) Protection of Stratospheric Ozone, 63 Fed. Reg. at 11,085–86.
actual fires." Based on these findings, the HTOC noted that limiting unnecessary discharges, changing testing and training procedures, and identifying halon alternatives would assist in protecting the ozone layer.

After implementation of the Montreal Protocol, the fire protection community and other organizations started to conserve halon reserves in anticipation of the "impending ban of the production and import of halons 1211, 1301, and 2402 that occurred on January 1, 1994." Nonetheless, even though developed countries banned production of halons on January 1, 1994 and developing countries expect to phase-out production by January 1, 2010, the concentration level of these powerful ozone destroyers is still rising because of their long atmospheric lifetime.

II. WHAT DOES THIS MEAN FOR THE CIVIL AVIATION INDUSTRY?: A NEED FOR HALON ALTERNATIVES

In the two decades after implementing the Montreal Protocol, the parties to the agreement and various industries have worked hard to identify halon substitutes and alternative technologies. As a result, the need for halons for new applications as well as old applications has significantly decreased in most industries. However, for some industries such as the military, the merchant marine community, the oil and gas production industry, and the civil aviation industry, the reliance on halons in fire suppression applications has caused problems in transitioning away from halons. This transition has been especially slow for the civil aviation industry, which still depends on halons for its fire protection applications in existing and new aircraft models.

To assist in the identification of halon alternatives for the various industries, the EPA developed the Significant New Alternatives Policy (SNAP) Programme and the U.K. formed the Halon Alternatives Group (HAG) to create the Toxicological Report on

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69 Id.
70 Id.
71 Gillespie, supra note 20, at 79. Halons possess a long atmospheric life that allows them to exist in the atmosphere for an extended period of time, up to hundreds of years, and cause destruction. Id.
72 Catchpole et al., supra note 4, at 7.
73 Id.
74 Id.
75 Id.
Alternative Agents to Halon. These programs research an alternative agent's toxicity, global warming potential, commercial availability, ozone-depleting potential, and other effects on the environment and evaluate the overall risk to human health and the environment from use of that alternative agent. "The SNAP Programme's evaluations and the EPA's determinations of the acceptability or otherwise of substitutes for Halon 1301 and Halon 1211 are published through formal notices and rules . . . and are legally binding in the United States."77

As for the civil aviation industry's response to the destructive nature of halons and the need to identify less harmful alternatives, the U.S. Federal Aviation Administration (FAA) created a program for identifying, testing, and certifying non-halon fire extinguishing and suppression systems on aircraft.78 The purpose of this program was to create performance criteria and certification methods for developing Minimum Performance Standards (MPS) to test the halon alternatives.79 Although the FAA leads the program and carries out most of the testing, the program, like the Montreal Protocol, is a global effort and contains participants from all aspects of the aviation industry. The Joint Aviation Authorities (JAA) in Europe, the Civil Aviation Authority (CAA) in the United Kingdom, and Transport Canada Aviation (TCA) are all involved with the program.80 Other program participants include "aviation regulatory authorities, other government agencies involved in research and development, airframe manufacturers, airlines, industry associations, manufacturers and suppliers of fire protection equipment and agents, and researchers."81

Additionally, the FAA and the other agencies set up the International Halon Replacement Working Group (IHRWG), currently known as the International Aircraft Systems Fire Protection Working Group (IASFPWG), in 1993 to provide feedback for the program.82 At its first meeting, the IHRWG created task groups to develop FAA test protocols for the four major

76 Id.
77 Id. at 6, 7.
78 HUGHES ASSOCs. & ICF CONSULTING, supra note 54, at 5.
79 Id.
80 Id.
81 Id.
applications of halon fire protection systems on aircraft.\textsuperscript{83} The four major applications include lavatory trash receptacle protection, handheld extinguishers, engine nacelles and auxiliary power units (APUs), and cargo compartments.\textsuperscript{84}

Based on the work of these task groups, the FAA developed six general requirements for halon alternatives. First, the alternative should provide the same level of protection as the current halon in use and thus should be suitable for extinguishing the class of fire likely to occur.\textsuperscript{85} Second, the alternative and its byproduct used in handheld extinguishers must have an acceptable toxicity for use around people.\textsuperscript{86} Next, the alternative "should be recognized by a technical, listing, or approval organization (e.g., NFPA, UL, FMRC) as suitable for the intended purpose."\textsuperscript{87} The alternative should be compatible with the other materials used in the fire extinguishing system as well as the materials in the surrounding areas where the system may be used.\textsuperscript{88} The alternative should also be in compliance with the Montreal Protocol and should not consist of another ozone-depleting chemical barred under the agreement.\textsuperscript{89} Finally, the alternative "must have a near-zero ozone depletion potential (ODP), and a low global warming potential (GWP) and atmospheric lifetime (ALT) are desirable."\textsuperscript{90}

A. LAVATORY TRASH RECEPTACLE PROTECTION

As a result of two incidents, the FAA proposed that aircraft should have an automatic fire extinguisher that discharges into a lavatory trash receptacle.\textsuperscript{91} The first incident relates to an aircraft cabin fire on a 1983 Air Canada flight that caused the

\textsuperscript{83} Hughes Assocs. \& ICF Consulting, supra note 54, at 5.
\textsuperscript{84} Id.; Hughes Assocs. \& ICF Consulting, supra note 54, at 5; Hughes Assocs. \& ICF Consulting, supra note 54, at 5; Hughes Assocs. \& ICF Consulting, supra note 54, at 5; Hughes Assocs. \& ICF Consulting, supra note 54, at 5.
\textsuperscript{85} Id.; Hughes Assocs. \& ICF Consulting, supra note 54, at 5; Hughes Assocs. \& ICF Consulting, supra note 54, at 5; Hughes Assocs. \& ICF Consulting, supra note 54, at 5; Hughes Assocs. \& ICF Consulting, supra note 54, at 5.
\textsuperscript{86} Id.; Hughes Assocs. \& ICF Consulting, supra note 54, at 5; Hughes Assocs. \& ICF Consulting, supra note 54, at 5; Hughes Assocs. \& ICF Consulting, supra note 54, at 5; Hughes Assocs. \& ICF Consulting, supra note 54, at 5.
\textsuperscript{87} Id.; Hughes Assocs. \& ICF Consulting, supra note 54, at 5; Hughes Assocs. \& ICF Consulting, supra note 54, at 5; Hughes Assocs. \& ICF Consulting, supra note 54, at 5; Hughes Assocs. \& ICF Consulting, supra note 54, at 5.
\textsuperscript{88} Id.; Hughes Assocs. \& ICF Consulting, supra note 54, at 5; Hughes Assocs. \& ICF Consulting, supra note 54, at 5; Hughes Assocs. \& ICF Consulting, supra note 54, at 5; Hughes Assocs. \& ICF Consulting, supra note 54, at 5.
\textsuperscript{89} Id.; Hughes Assocs. \& ICF Consulting, supra note 54, at 5; Hughes Assocs. \& ICF Consulting, supra note 54, at 5; Hughes Assocs. \& ICF Consulting, supra note 54, at 5; Hughes Assocs. \& ICF Consulting, supra note 54, at 5.
\textsuperscript{90} Id.; Hughes Assocs. \& ICF Consulting, supra note 54, at 5; Hughes Assocs. \& ICF Consulting, supra note 54, at 5; Hughes Assocs. \& ICF Consulting, supra note 54, at 5; Hughes Assocs. \& ICF Consulting, supra note 54, at 5.
\textsuperscript{91} Id.; Hughes Assocs. \& ICF Consulting, supra note 54, at 5; Hughes Assocs. \& ICF Consulting, supra note 54, at 5; Hughes Assocs. \& ICF Consulting, supra note 54, at 5; Hughes Assocs. \& ICF Consulting, supra note 54, at 5.
death of twenty-three individuals. The second incident relates to another 1983 aircraft cabin fire on a plane at Tampa International Airport that caused an evacuation of the plane with no injuries. In response to the FAA proposal, the U.S. Department of Transportation issued Federal Aviation Regulation (FAR) 14 C.F.R. 121.308b, requiring each lavatory of a passenger-carrying airplane to have "a built-in fire extinguisher for each disposal receptacle . . . that must be designed to discharge automatically into each disposal receptacle upon occurrence of a fire in the receptacle." Furthermore, the disposal receptacle must also comply with the design and construction requirements under FAR 14 C.F.R. 25.853.

The current lavatory fire extinguisher systems use Halon 1301 as the fire-extinguishing element. As for identifying halon alternatives for these lavatory systems, the FAA finalized the MPS for the lavatory systems in 1997. Besides the general requirements for the halon alternatives, the MPS for the lavatory systems also requires the alternative to be able to extinguish a paper towel fire and to have a toxicity level of "No Observed Adverse Effect Level" if the alternative was released into the entire lavatory and not just the trash receptacle. The FAA tested four alternatives, HFC-125, HFC-227ea, HFC-236fa, and Envirogel, using the 1997 MPS for the lavatory systems.

These alternatives represent the various HFCs that the FAA tested to replace the halon agents in the lavatory trash receptacles with halocarbon systems. Envirogel also contains a halo-
carbon component as it is not one specific system. Instead, it is the market name that refers to a variety of formulations that blend halocarbons, dry chemicals, and gels together to create a fire suppression agent. Two of these alternatives, HFC-227ea and HFC-236fa, have test results that meet the MPS requirements.

Once alternatives are identified, aircraft manufacturers and suppliers begin their own testing and approval process. In 2004, Boeing reported that HFC-227ea passed several tests in their current model aircraft and the company was currently in the process of getting FAA approval of a Type Certificate for its alternative Lavex bottle assembly and installation process. Another manufacturer, Airbus, performed tests on a lavatory system using HFC-236fa, which was approved. As of 2006, Airbus has installed the alternative system in its Airbus A340-600 model.

B. HANDHELD EXTINGUISHERS

Under FAR 14 C.F.R. 25.851, the FAA requires aircraft to have handheld fire extinguishers in passenger compartments. These FAA regulations require a certain number of extinguishers per plane depending on the number of passengers each aircraft holds. The regulations also require that a certain number of extinguishers contain Halon 1211 or an equivalent extinguishing agent once the aircraft passenger capacity exceeds thirty passengers. The total number of extinguishers per aircraft range from one extinguisher for 7-30 passenger aircraft to eight for 601-700 passenger aircraft.

101 Tapscott & Speitel, supra note 82, at 40; Wickham, supra note 57, at 26.
102 Tapscott & Speitel, supra note 82, at 40; Wickham, supra note 57, at 26.
103 Hughes Assocs. & ICF Consulting, supra note 54, at 12–13; Catchpole et al., supra note 4, at 7.
105 Id. at 12.
106 Catchpole et al., supra note 4, at 7.
The FAA initially chose Halon 1211 for use in the handheld extinguishers based on the hijacking/arsonist scenario, where gasoline is smuggled onto the plane and used to ignite a fire on a seat cushion. The hijacking/arsonist scenario is still one of the tests required under the MPS for handheld extinguishers. Besides meeting the general requirements for alternatives, the alternatives must also meet three other requirements. First, the alternative must show that it can extinguish fires caused by flammable liquids and flammable gases as well as fires caused by electrical equipment. Second, the alternative must pass the “hidden fire test” by extinguishing fires in inaccessible areas as effectively as Halon 1211. Finally, the alternative must have an acceptable toxicity level for use around people.

The FAA finalized the MPS for handheld extinguishers in August 2002, and so far, the FAA has identified approximately six alternatives, including HFC-236fa, HFC-236fa/HFC-23, HCFC Blend B, HCFC Blend E, and two versions of Envirogel, for testing. Of the alternatives tested, three of the alternatives, HFC-227ea, HFC-236fa, and HCFC Blend B, have met the MPS requirements. The next step in the process is the aircraft manufacturers’ internal qualification procedures of testing and obtaining approval for the alternative systems. Due to the fact that these alternatives require more weight, and thus a larger container, than Halon 1211, the internal qualification process will include “qualifying a new bracket for the extinguisher, finding a location that supports the larger extinguisher, and conducting structural analyses to ensure that the larger, heavier extinguisher and bracket can meet mandated load require-

111 Hughes Assocs. & ICF Consulting, supra note 54, at 14.
112 Id.
114 Hughes Assocs. & ICF Consulting, supra note 54 at 14.
115 Hughes Assocs. & ICF Consulting, supra note 54, at 14; Webster, supra note 113, at 1–3.
116 Hughes Assocs. & ICF Consulting, supra note 54, at 15; Webster, supra note 113, at 1–3.
117 Hughes Assocs. & ICF Consulting, supra note 54, at 19–20; Webster, supra note 113, at 6–7; Catchpole et al., supra note 4, at 7.
118 Hughes Assocs. & ICF Consulting, supra note 54, at 16; Catchpole et al., supra note 4, at 7.
119 Hughes Assocs. & ICF Consulting, supra note 54, at 20.
As the handheld extinguisher is still in the internal qualification phase, there have been no alternatives installed yet on aircraft. As the handheld extinguisher is still in the internal qualification phase, there have been no alternatives installed yet on aircraft.

C. ENGINE NACELLE AND AUXILIARY POWER UNIT (APU) FIRE PROTECTION SYSTEMS

Another aircraft application that requires a fire suppression system is the engine nacelle and APU compartments. Under FAR 14 C.F.R. 25.1195, the FAA requires fire suppression systems in engine nacelle and APU compartments to meet three standards. First, the system must be able to control fires in the designated fire zones of the engine nacelles and APUs, which encompass all areas "except for combustor, turbine, and tail pipe sections of turbine engine installations that contain lines or components carrying flammable fluids or gases for which it is shown that a fire originating in these sections can be controlled." Second, the system must be "effective in quantity of agent, rate of discharge, and distribution by live test during actual or simulated flight conditions." Finally, the system must provide sufficient and simultaneous protection through the entire compartment.

Engine nacelles and APU compartments usually deal with Class B fires, which are caused by igniting aviation fuel, hydraulic fluid, and other lubricants. Currently, these systems use Halon 1301 to extinguish these fires. One study expected the FAA to publish a finalized MPS for engine nacelles and APU compartments by 2005, but none was available as of 2006. However, there are still halon alternatives available for testing for these systems. The Engine Nacelle Task Group focused on the program implemented by the U.S. Air Force to identify

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120 Id.
121 Catchpole et al., supra note 4, at 7.
127 Id. at 25.
128 Id.
129 Catchpole et al., supra note 4, at 7.
halon alternatives for its engine nacelle and APU compart-
ments. The U.S. Air Force identified three alternatives: FIC-
1311, HFC-125, and HFC-227ea. Of these alternatives, the
U.S. Air Force developed systems using HFC-125 for its engine
nacelles. The military sector has already implemented these
alternative systems in a few of its fighter jets and helicopter mod-
els. Nonetheless, the civil aviation industry has not been able
to identify any alternatives that meet the FAA’s MPS for engine
nacelles because the MPS have not yet been finalized. For
this reason, there are also no alternatives installed on any air-
craft models.

D. CARGO COMPARTMENT FIRE PROTECTION

The fourth civil aircraft application of halons is the cargo
compartment fire protection systems. The Federal Air Regu-
lations use cargo accessibility and the type of detection and sup-
pression systems found in each area to classify the cargo
compartments. In addition, the number of compartments re-
quiring fire suppression systems increased based on an FAA rul-
ing that eliminated Class D compartments, which did not
require smoke detection or fire suppression systems. These
compartments must now meet Class C or Class E requirements,
which both require smoke detection and fire suppression sys-
tems. Other FAA regulations require that cargo compart-

130 Hughes Assocs. & ICF Consulting, supra note 54, at 25.
131 Id.
132 Id.
133 Id. at 27.
134 Id. at 25; Catchpole et al., supra note 4, at 7.
135 Catchpole et al., supra note 4, at 7.
136 Hughes Assocs. & ICF Consulting, supra note 54, at 5.
137 Id. at 29; Cargo Compartment Classification, 14 C.F.R. § 25.857 (2007).
138 Revised Standards for Cargo or Baggage Compartments in Transport Cate-
gory Airplanes, 63 Fed. Reg. 8032, 8033 (Feb. 17, 1998); Hughes Assocs. & ICF
Consulting, supra note 54, at 29. “A Class D cargo compartment is an inaccessible
compartment that does not have a fire or smoke detection system and a fire
suppression system.” Id. at 42 (citing 14 C.F.R. § 25.857).
139 Revised Standards for Cargo or Baggage Compartments, 68 Fed. Reg. at
8033; Hughes Assocs. & ICF Consulting, supra note 54, at 29. A Class C com-
artment is a compartment that contains a separate smoke and fire detection
system that alerts the pilot or flight engineer station of a fire, a fire suppression
system that is controlled from the cockpit, devices to keep hazardous quantities
of smoke and fire away from passengers and crew members, and means to con-
trol ventilation in the compartment to assist the fire suppression system. 14
C.F.R. § 25.857. A Class E compartment is a cargo-only compartment that con-
tains a separate smoke and fire detection system that alerts the pilot or flight
ment systems meet three additional requirements. First, the built-in fire extinguishing system must be installed in such a manner that harmful extinguishing agents are not likely to enter personnel compartments and that discharge of the system would not cause structural damage. Second, the system must be capable of handling the size of a fire that is most likely to occur in the compartment. Finally, the regulations also require the systems to pass flight tests concerning "compartment accessibility, entry of hazardous quantities of smoke or extinguishing agent into occupied compartments, and the dispersion of the extinguishing agent in Class C compartments."

Four types of fires are likely to occur in cargo compartments: bulk load fires, containerized fires, surface burning fires, and aerosol can explosions. Current aircraft models use Halon 1301 as the extinguishing agent in the cargo compartment systems. The MPS for cargo compartments test all four types of fires. The FAA finalized the MPS for cargo compartments in April 2003. However, the MPS includes a "short" and "long" version of the aerosol can test and there is controversy over whether the long-version test provides a sufficient safety standard for identifying a halon alternative. The difference between the two versions of tests is that the "short" version relates to the original procedure that the FAA used to test gaseous extinguishing agents, and the "long" version relates to the specially-developed test for non-gaseous systems, such as water spray systems. The controversy over the different versions is due to

engineer station of a fire, controls to shut off the airflow to and within the compartment, devices to keep hazardous amounts of smoke and flames away from the flight crew compartment, and accessible crew emergency exits. 14 C.F.R. § 25.857.

140 Hughes Assocs. & ICF Consulting, supra note 54, at 29.
141 14 C.F.R. § 25.851(b); Hughes Assocs. & ICF Consulting, supra note 54, at 29.
142 14 C.F.R. § 25.851(b); Hughes Assocs. & ICF Consulting, supra note 54, at 29.
143 Cargo or Baggage Compartments, 14 C.F.R. § 25.855(h) (2007); Hughes Assocs. & ICF Consulting, supra note 54, at 29.
145 Id.
146 Id.
147 Id. at 31; see generally John Reinhardt, Fed. Aviation Admin., DOT/FAA/AR-TN0316, Minimum Performance Standard for Aircraft Cargo Compartment Halon Replacement Fire Suppression Systems (2003). (This document has now been replaced by DOT/FAA/AR-TN05/20).
148 Hughes Assocs. & ICF Consulting, supra note 54, at 31–32.
149 Id. at 32.
the fact that the “long” version of the aerosol can test may not provide the same level of safety as Halon 1301.\textsuperscript{150}

The FAA has identified four alternatives for testing, including water mist systems, water mist/nitrogen systems, HFC-125, and bromotrifluoropropene.\textsuperscript{151} From its testing, the FAA found only one alternative, the water mist/nitrogen system, that met the cargo compartment MPS.\textsuperscript{152} However, no airframe manufacturer appears to be in the process of performing the internal qualifications procedures for this alternative because the water mist/nitrogen system only passed the “long” version of the aerosol can test and the airframe manufacturers do not believe that the alternative system provides the same level of safety as the current halon systems.\textsuperscript{153}

E. Barriers to the Use of Halon Alternatives in the Four Applications

The alternative fire suppression systems face different barriers to implementation depending on the application and its status in the transition process.\textsuperscript{154} In a 2004 report to the EPA, ICF Consulting (ICF) identified four main barriers in the transition away from halons in the civil aviation industry.\textsuperscript{155} The four main barriers are as follows:

1. the lack of a regulatory mandate to replace halons;
2. regulatory concerns associated with some of the halon alternatives;
3. space, weight, and cost penalties of the halon alternatives; and
4. the lack of effective leadership within the aviation community in setting non-regulatory halon phase-out target dates or goals.\textsuperscript{156}

These barriers represent the main barriers affecting the industry that ICF identified after evaluating the technical, economic, and

\textsuperscript{150} Id. at 33.
\textsuperscript{151} Id.; Catchpole et al., supra note 4, at 7.
\textsuperscript{152} HUGHES ASSOCS. & ICF CONSULTING, supra note 54, at 33; Catchpole et al., supra note 4, at 7.
\textsuperscript{153} HUGHES ASSOCS. & ICF CONSULTING, supra note 54, at 33; Catchpole et al., supra note 4, at 7.
\textsuperscript{154} HUGHES ASSOCS. & ICF CONSULTING, supra note 54, at 1.
\textsuperscript{155} Id. at 2.
\textsuperscript{156} Id.
regulatory barriers associated with each of the four applications on civil aircraft.\textsuperscript{157}

1. Technical Barriers

Only the lavatory trash receptacle application appears to have no technical barrier to implementing an alternative system.\textsuperscript{158} Besides having no technical barriers to implementation, the HTOC noted that the alternatives identified to replace Halon 1301 in lavatory systems are "technically superior and economically preferable to Halon 1301 units."\textsuperscript{159} Additionally, only document changes and no additional design work are necessary to implement the lavatory system alternatives into the aircraft.\textsuperscript{160}

Although the alternatives for the handheld extinguishers provide the same level of safety as the current Halon 1211 systems, they are less effective on a weight basis and occupy more space than the Halon 1211 units.\textsuperscript{161} For this reason, there may be some technical barriers to implementing the alternative handheld systems.\textsuperscript{162} The alternative handheld systems will also require new engineering and designs, which the FAA will need to approve prior to implementing the systems in the aircraft.\textsuperscript{163}

Nonetheless, design and approval obstacles are minimal for handheld extinguishers as compared to the technical barriers facing the implementation of an alternative system for the engine nacelles and APU systems. The MPS for this system is currently under revision and is not available for review.\textsuperscript{164} This revision represents the third revision for this MPS and, at this point, the MPS only addresses tests for the engine nacelles and not the APU systems.\textsuperscript{165} The IHRWG decided to cease pursuing criteria for the APUs because the group found that the criteria

\begin{footnotesize}
\begin{itemize}
\item \textsuperscript{157} Id.
\item \textsuperscript{158} Id. at 13.
\item \textsuperscript{159} Id.
\item \textsuperscript{160} Id.
\item \textsuperscript{161} Id. at 21.
\item \textsuperscript{162} Id. at 20.
\item \textsuperscript{163} Id. at 21.
\item \textsuperscript{165} Id.; Engine Halon Replacement, supra note 82.
\end{itemize}
\end{footnotesize}
for the engine nacelles far exceeded the criteria for the APUs.\textsuperscript{166} Therefore, the biggest setback for the engine nacelle systems is that there is no finalized MPS, making it difficult to identify an alternative agent for this application and to truly understand all of the barriers to implementing an alternative system.\textsuperscript{167}

Conversely, having a finalized MPS does not limit the technical barriers for the cargo compartment application. This is because the finalized MPS for the cargo compartment contains a "long" version of the aerosol can test that "is viewed by some, [including Boeing], as a radical departure from the original objective of providing equivalent levels of safety to halons."\textsuperscript{168} Because of the "long" version test, the airframe manufacturers may not accept the final MPS or the alternatives identified under this testing, and instead continue to search for an alternative element that meets the original "short" version of the test.\textsuperscript{169} Another technical barrier for this application is the alternative systems' (the water mist/nitrogen systems') dependence on Onboard Inert Gas Generating Systems (OBIGGS).\textsuperscript{170} This dependence is an issue because while military cargo aircraft have used OBIGSS systems, commercial aircraft have not previously used this technology.\textsuperscript{171} Moreover, other technical barriers may exist with this application. However, those technical barriers are unknown because additional testing is necessary if other alternatives are selected for qualification and certification for civil aircraft.\textsuperscript{172}

2. Economic Barriers

Similar to technical barriers, the lavatory trash receptacle is the only application that does not appear to have any economic barriers to implementing the alternative system.\textsuperscript{173} This is because the alternatives identified (HFC-227ea, HFC-236fa, and Envirogel) work better than the current Halon 1301 system, without adding any weight or design differences.\textsuperscript{174} As there are

\textsuperscript{167} HUGHES ASSOCs. & ICF CONSULTING, supra note 54, at 28.
\textsuperscript{168} Id. at 32–33.
\textsuperscript{169} Id. at 33.
\textsuperscript{170} Id. at 34.
\textsuperscript{171} Id.
\textsuperscript{172} Id.
\textsuperscript{173} Id. at 13.
\textsuperscript{174} Id.
no design or weight differences between the alternative systems and the current Halon 1301 systems, there are no additional costs for changing the design or substantial weight or space penalties.\textsuperscript{175}

On the other hand, the alternative systems for the handheld extinguishers pose both weight and space penalties due to the fact that the alternatives for the handheld systems are less effective on a weight basis and take up more space than the Halon 1211 systems.\textsuperscript{176} The gross weights of the alternative elements for the handheld extinguishers, HFC-227ea, HFC-236fa, and HCFC Blend B units, are almost twice that of Halon 1211.\textsuperscript{177} For example, the Halon 1211 extinguishers with the brackets weigh approximately 5.5 pounds; whereas the alternative extinguishers with the brackets weigh approximately ten pounds.\textsuperscript{178} In addition, the dimensions of the Halon 1211 extinguishers are 0.076 cubic feet, but the dimensions for the alternative extinguishers range from 0.188 to 0.368 cubic feet.\textsuperscript{179}

One can estimate the additional costs of the added weight from these alternatives. The FAA estimates that, depending on the aircraft model, the incremental fuel consumption ranges from 0.003 to 0.010 gallons per flight hour per pound of weight added.\textsuperscript{180} The FAA also estimates that all aircraft fly approximately 4,400 hours per year.\textsuperscript{181} Therefore, the additional fuel required per year per pound based on the incremental fuel consumption data ranges from 13.2 gallons (4,400 hour x 1 pound x 0.003 gallons/hour/pound) to 44 gallons (4,400 hour x 1 pound x 0.010 gallon/hour/pound).\textsuperscript{182} The U.S. Department of Transportation reports that the average jet fuel price for airlines was $1.97 per gallon for 2006.\textsuperscript{183} Based on 2006 jet fuel prices, the additional cost of carrying one more pound of weight ranges from $26 (13.2 gallons x $1.97) to $87 (44 gallons x $1.97). Therefore, the additional cost of carrying a handheld extinguisher with an alternative agent rather than an extin-

\textsuperscript{175} Id.
\textsuperscript{176} Id. at 21.
\textsuperscript{177} Id.
\textsuperscript{178} Id.
\textsuperscript{179} Id.
\textsuperscript{180} Id. at 21–22.
\textsuperscript{181} Id.
\textsuperscript{182} Id.
guisher with Halon 1211 ranges from $117 ($26 x 4.5 pounds) to $392 ($87 x 4.5 pounds).

Although the additional weight of 4.5 pounds (10 pounds per alternative extinguisher – 5.5 pounds per Halon 1211 extinguisher) per extinguisher and a maximum additional cost of $392 per extinguisher may seem insignificant, any additional cost will serve as an economic barrier to implementing these new systems, especially in light of the current status of the industry. Furthermore, the costs may seem insignificant in proportion to an airline's jet fuel costs for the year, considering that for fiscal year 2005 AMR Corporation (American Airlines) and Southwest Airlines reported aircraft fuel expenses of $5.6 billion and $1.3 billion, respectively. However insignificant they may seem, they are still additional costs. These costs add up, and the additional cost range of $117 to $392 is only for one extinguisher. As mentioned previously, some aircraft models require up to eight handheld extinguishers per FAA regulations, which would translate into additional costs ranging from $936 (8 extinguishers x 4.5 pounds x $26) to $3,132 (8 extinguishers x 4.5 pounds x $87) per aircraft.

Additional costs are also expected with the alternative units for the engine nacelle systems, because all of the alternative elements that the IASFPWG is currently testing weigh more than the Halon 1301 used in the current systems. However, the extent of the additional costs is still unknown because the IASFPWG has not finalized the MPS for this application, and the replacement agents are thus not definitive. Therefore, the economic barriers could be significant considering the cost of the agent and whether any additional design work is necessary.

As for the cargo compartment systems, additional costs are expected with implementing the alternative systems because the IASFPWG has already discovered that one of the alternative agents tested, HFC-125, requires more agent than the current Halon 1301 systems. Due to the need for more agent, the IASFPWG expects the alternative system to add significant weight penalties, and thus significant cost penalties, for each aircraft. There may also be additional costs from design work or

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185 HUGHES ASSOCS. & ICF CONSULTING, supra note 54, at 28.
186 Id.
187 Id. at 34.
188 Id.
agent costs depending on the alternative selected for qualification and certification.

Overall, the economic barrier for three of the aviation applications—handheld systems, engine nacelle and APU systems, and cargo compartment systems—is the fact that halon systems are readily available at lower costs than the new alternative systems. The prices for the alternative agents are almost ten times greater than the price of halons. Thus, there is little economic incentive for the airlines to implement these systems and incur any additional costs. This disincentive is only increased by the belief that halon supplies will be available for at least another decade, leaving no need to address this issue immediately.

3. Regulatory Barriers

There appear to be no regulatory barriers for any of the applications, but that may just be the problem. There are no regulatory barriers in the sense that there is no regulation ordering airlines to transition from the use of halons to other alternative agents. Other sectors, such as the military, the merchant marine community, and the oil and gas production industry, did not need a mandate in order to adopt applications that used halon alternatives. However, there is a need for regulation in order to incentivize civil airlines to implement alternative systems. “Until supplies of recycled halons either become cost-prohibitive to procure or simply unavailable, or until policy changes are implemented that push the transition away from halons, the civil aviation industry lacks an immediate incentive to replace halons” in any of the applications.

Although there may be no regulation to force the civil aviation industry to transition away from halons, there are still two regulatory issues that the civil aviation industry faces during this transition. First, the civil aviation industry is a highly-regulated industry and most of its actions must get approval from the FAA. Second, in the search for alternative systems and halon replacements, the civil aviation industry must consider the other substances regulated by the Montreal Protocol.

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189 Id. at 21–23.
190 Id. at 3.
191 Id. at 23.
192 Id.
193 Id.; Catchpole et al., supra note 4, at 7.
194 HUGHES ASSOCs. & ICF CONSULTING, supra note 54, at 23.
For example, the Montreal Protocol places limits on the consumption of HCFCs by developed countries that are parties to the agreement.\textsuperscript{195} The agreement requires that the United States and other developed countries meet specific deadlines in reducing their consumption and production of HCFCs.\textsuperscript{196} Moreover, the EPA has decided to accelerate the phase-out of the most damaging HCFCs (HCFC-141b, HCFC-142b, and HCFC-22) in order to meet the deadlines set by the Montreal Protocol.\textsuperscript{197} The next deadline for the current phase-out schedule required by the EPA is 2010, when consumption of HCFCs must decrease by sixty-five percent from the original baseline, and there is to be no production and no importing of HCFC-142b and HCFC-22, except for use in equipment made before January 1, 2010.\textsuperscript{198} Also, the EPA requires complete phase-out by 2030, when there must be no consumption and no production or importation of any HCFCs.\textsuperscript{199} Therefore, the Montreal Protocol may limit the potential alternatives depending on whether UNEP/HTOC identified the agent as an ozone-depleting chemical and scheduled it for phase-out. Additionally, some elements that the civil aviation industry is currently testing may be identified as harmful to the ozone at a later date, which could slow down the process significantly.

Of the three types of barriers, the technical and regulatory barriers appear to be the least restrictive for the civil aviation industry. The regulatory barriers are the least restrictive because there are no regulations directing the transition away from halons, although this may be the problem. As for solving the technical barriers, the industry needs to prioritize identifying alternative agents for the various applications. However, resolving the technical barriers may be the most time-consuming considering how long it has taken the industry to identify the current list of alternative agents. Additionally, the airlines may not have much time to implement halon alternatives, due to the available halon supply. Nonetheless, the airlines have more time than they have money, and so the economic barriers


\textsuperscript{196} Montreal Protocol, supra note 1, art. 2F; HCFC Phaseout Schedule, supra note 195.

\textsuperscript{197} HCFC Phaseout, supra note 195.

\textsuperscript{198} Id.

\textsuperscript{199} Id.
are the barriers that are the most restrictive and difficult to overcome. With knowledge of these barriers, the civil aviation industry must decide how to proceed with the transition process.

III. WHERE SHOULD THE CIVIL AVIATION INDUSTRY GO FROM HERE?: THE NEXT STEP FOR THE CIVIL AVIATION INDUSTRY AND THE OBSTACLES IT FACES

ICF Consulting (also known as ICF International) is "a global professional services firm [that has partnered] with government and commercial clients to deliver consulting services and technology solutions in energy, environment, transportation, social programs, defense, and homeland security" since 1969.200 Hughes Associates, Inc. "is a global company with leading fire protection consultants and engineers, and fire investigators that specialize in fire testing, fire modeling, and fire protection design."201 As a part of its report to the EPA, ICF Consulting and ICF’s subcontractor, Hughes Associates, Inc., (collectively ICF) identified the steps and the estimated time to complete the transition away from the current halon systems to alternative extinguishing units in commercial aircraft applications.202 The transition process involves six steps.203 The first step is the finalization of Minimum Performance Standards (MPS) for the four fire suppression applications.204 The next step, which ICF estimates to take six to twelve months to complete, entails the FAA testing alternative agents under the MPS for each of the four applications.205 Third, the airframe manufacturers must perform qualification testing of the alternative agents and systems.206 ICF expects this testing to take twelve to eighteen

202 HUGHES ASSOCs. & ICF CONSULTING, supra note 54, at 37. Under a contract with the EPA, ICF Consulting and its subcontractor, Hughes & Associates, prepared a report summarizing the transition process away from halons for the civil aviation industry. Id. at 1. Peer reviewers, which included Jeff Gibson of American Pacific, Dave Catchpole of BP Exploration, Steve McCormick of the U.S. Army, and representatives of Kidde Aerospace and The Boeing Company, reviewed ICF's draft final report. Id. ICF made edits and corrections to the report based on the peer reviewers' comments. Id.
203 Id. at 37.
204 Id.
205 Id.
206 Id.
months to complete.\textsuperscript{207} The fourth step, which ICF estimates will require three to six months to complete, involves preparing and submitting a modified type certification for the new system to the FAA.\textsuperscript{208} Next, the FAA must approve the modified type certification submitted by the aircraft manufacturers.\textsuperscript{209} ICF expects the FAA approval process to take three to six months to complete for each certification request.\textsuperscript{210} Finally, the last step, which ICF estimates to require another three to six months to complete, consists of designing and implementing the approved alternative system into the aircraft model.\textsuperscript{211}

Currently, the civil aviation industry has not even completed the first step for all of the applications because the finalized MPS for engine nacelles is still outstanding.\textsuperscript{212} The FAA has been in the process of finalizing the MPS for engine nacelles for at least two years.\textsuperscript{213} Moreover, the industry has only reached the final step of implementing an alternative system for one application, the lavatory system, and in only one aircraft model, the Airbus A340-600.\textsuperscript{214} This emphasizes that the already time-consuming process is taking even more time than expected with many delays.

Despite the many levels of approval required to implement a new design and safety system, "the lack of a regulatory requirement to eliminate halon use [is most] cited as a reason for the slow transition away from halons in civil aviation."\textsuperscript{215} Furthermore, the regulations that do exist actually allow the civil aviation industry to postpone the transition process.\textsuperscript{216} These regulations allow the civil aviation industry to use recycled halons to avoid the costs of retiring current halon systems early, and thus give no incentive to the industry to search for alternatives.\textsuperscript{217} Therefore, the airlines continue to use halon from
stockpiles and retired equipment to supply their old and new aircraft.\textsuperscript{218}

On the other hand, the lack of regulations did not prevent other industries, such as the military, the merchant marine community, and the oil and gas production industry, from making the transition away from halons.\textsuperscript{219} These sectors also faced an unregulated environment in terms of the halon transition and significant cost penalties for redesigning fire suppression systems and using alternative agents, but they were nevertheless able to make the transition successfully.\textsuperscript{220} An important key to the success of these sectors’ transitions was their ability to “maintain existing systems (thus retaining the initial equipment investment) while adopting halon alternatives in all new installations.”\textsuperscript{221}

However, the bigger key for these industries was the fact that they were able to identify an alternative more easily. The fire protection industry as a whole experienced a setback in identifying halon alternatives.\textsuperscript{222} From the signing of the Montreal Protocol in 1987 to the halon production ban in 1994, the fire protection industry was generally optimistic that it would be able to find alternative agents to halons that would be more effective than the halons themselves.\textsuperscript{223} Nonetheless, after years of research, the industry realized that it would have to make compromises in the replacement agents and that it had spent a lot of time and money in creating alternatives that were not commercially viable.\textsuperscript{224} The compromises stemmed from the fact that the alternative agents identified were less effective and more expensive than halons.\textsuperscript{225}

Other industries have found the process of identifying alternatives easier than the civil aviation industry for several reasons. For the oil and gas production sector, the main difference is that the sector does not face the same space issues as the civil aviation industry.\textsuperscript{226} The oil and gas production sector replaced halon systems primarily with water mist systems in new designs

\begin{flushright}
\textsuperscript{218} Id.
\textsuperscript{219} Id. at 7–8.
\textsuperscript{220} Id.
\textsuperscript{221} Id. at 8.
\textsuperscript{222} Wickham, supra note 57, at 11–12.
\textsuperscript{223} Id.
\textsuperscript{224} Id.
\textsuperscript{225} Id. at 12.
\textsuperscript{226} Id. at 20.
\end{flushright}
The main drawback with water mist systems is that the design and engineering process must ensure that there is a sufficient concentration of water released in the space to extinguish the fire. For the civil aviation industry, the weight of the water and the space needed to carry a sufficient amount of water creates greater cost and space penalties than it does for the oil and gas production sector, which is "relatively insensitive to weight and space requirements." Water for these systems is inexpensive, but the added weight from the amount of water necessary for these systems and the space needed for these systems would increase an aircraft's fuel costs.

On the other hand, the transition was easier for the merchant marine community because the industry was able to fall back on the systems it used prior to the implementation of halons. After the development of Halon 1301, the merchant marine community quickly moved from carbon dioxide systems to Halon 1301 systems for fire protection because halon was less expensive. Once halon production ceased and ship manufacturers could no longer install Halon 1301 on new vessels, the sector reverted back to the carbon dioxide systems because there was no regulation banning the carbon dioxide systems, the sector knew the systems worked, and it was a less expensive option compared to researching another halon alternative.

It is not that simple for the civil aviation industry. The aviation industry cannot fall back on old systems because most of its current applications were originally implemented with halon. For example, halons were readily available when the FAA implemented regulations requiring airframe manufacturers to install handheld extinguishers and lavatory trash receptacle extinguishers on all aircraft. Therefore, the first agents placed in these systems were Halon 1211 and Halon 1301, respectively. In addition, carbon dioxide systems are not the best option for the aviation industry due to the risks and cost penalties associated with these systems. The risks associated with carbon dioxide pri-

227 Id. at 19.
228 PHASE OUT OF HALONS, supra note 100, at 13.
229 WICKHAM, supra note 57, at 20.
230 Id.
231 Id. at 19.
232 Id.
233 Id.
235 WICKHAM, supra note 57, at 8–9.
Halon alternatives mainly relate to health effects and safety issues, making carbon dioxide a poor choice for the airlines, as they are responsible for the lives of their passengers and employees.\textsuperscript{236} Also, carbon dioxide itself is inexpensive, but the containers for the carbon dioxide are relatively heavy and would impose large cost penalties for the airlines.\textsuperscript{237}

It was also difficult for the military sector, which faces similar weight, space, and cost penalties to those faced in the civil aviation industry. However, unlike the civil aviation industry and the FAA, the Department of Defense implemented a multi-million-dollar research program to identify halon alternatives.\textsuperscript{238} In addition, not all of the fire suppression applications are the same for the military sector and the civil aviation industry. Some of the applications, specifically the applications for the U.S. Army and Navy, are more similar to the applications for the oil and gas production industry and merchant marine community.\textsuperscript{239} Nonetheless, the engine nacelle application is similar to the civil aviation industry, and the military believes that it has identified an alternative in HFC-125.\textsuperscript{240} The military sector implemented fire suppression systems with the HFC-125 alternative despite the space, weight, and associated cost penalties.\textsuperscript{241} However, the necessary quantity of the alternative agent was much less than the amount estimated by the Department of Defense.\textsuperscript{242} Therefore, the military sector was expecting to implement an alternative with greater penalties, and it was therefore easier to implement the alternative identified. The civil aviation industry may be able to use this alternative in its systems, but it must first finalize the MPS for this application.\textsuperscript{243}

Although the model used by the other industries to maintain old halon systems while implementing alternatives in the new systems may be helpful to the civil aviation industry, it may also be very difficult for the industry to follow. The average lifetime of a commercial aircraft ranges from twenty-five to thirty


\textsuperscript{237} Phase Out of Halons, supra note 100, at 18.

\textsuperscript{238} Wickham, supra note 57, at 11.

\textsuperscript{239} See id. at 31–32.

\textsuperscript{240} Id. at 32.

\textsuperscript{241} Hughes Assocs. & ICF Consulting, supra note 54, at 27.

\textsuperscript{242} Id.

\textsuperscript{243} Catchpole et al., supra note 4, at 7.
Due to the long useful lives of aircraft, it is likely to be expensive for the airlines to implement halon alternatives into the new aircraft and maintain the old halon systems while searching for alternative agents. However, without regulations pushing the airlines to transition away from halons, this high cost will be the economic incentive the industry needs to encourage the transition.

If the pressure that the civil aviation industry needs to hasten the transition away from halons does not come from regulations or the high cost, it is likely to come from the depleting halon supplies available for the industry's fire suppression systems. In its October 2006 meeting, the IASFWPG expressed concern that there are not adequate amounts of halon available to meet the civil aviation needs twenty to thirty years from now. The group also questioned whether there is enough Halon 1211 to support the life of the aircraft currently being produced because it is becoming increasingly difficult to find halon in the United States and Europe. The current estimates show that Europe has a five-year supply of halon remaining. Additionally, the price of the halon available is also rising, making the current fire suppression systems costly to maintain. Due to the status of the halon supply, there is a focus and concern in the aviation industry for airlines to bank and properly recycle halon. Therefore, the status of the halon supply also serves as an indirect economic incentive for the airlines to implement halon alternatives.

Overall, the economic incentives, rather than a regulatory mandate, are more likely to encourage the civil aviation industry to pursue halon alternatives more rigorously. The main reason for this is the current economic condition of the U.S. airline

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244 Id.
245 Id. at 8.
247 Id.
248 Id.
249 Id.
industry. Although the industry showed improvement in 2006 and the Air Transportation Association expects the industry to record earnings ranging from $2 to $3 billion dollars for the year, the industry is still struggling and trying to recover from the $35 billion in net losses that the industry reported over the past five years. The major airlines focused on "painstaking, ongoing cost reduction efforts and balance-sheet repair" for the past few years in order to improve their financial condition. However, the improved financial condition does not mean the struggle is over. The airlines still face high debt levels and remain susceptible to recession, fuel price increases, and extraordinary circumstances, such as natural disasters. Thus, the industry’s focus remains on controlling costs, and any additional costs, such as the ones associated with the fire suppression applications, are very unwelcome.

The emphasis on cutting expenses has overshadowed the need to implement halon alternatives and the airlines have not been in a hurry to implement any alternatives for this reason. Most of the halon alternatives that satisfy the MPS tests for each application, as well as the alternatives just identified for testing, all have associated weight and space penalties. These weight and space penalties translate into cost penalties because of the additional fuel and design work that is required to implement and maintain these systems. With the weight and cost penalties, the airlines are less than eager to implement these systems because of their negative impact on the bottom line. Nonetheless, while the civil aviation industry has been ignoring the transition process, the halon supply has been decreasing, and it has reached a point where either the civil aviation industry or the regulatory authorities needs to act.

Although there is a need for a plan of action from a regulatory body, a regulation or plan of action must be implemented with great care considering that other industries were successful in transitioning away from halon use without such regulation. The plan of action could be as simple as performing additional

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252 Id.
253 Id.
254 Id.
255 Id.
256 HUGHES ASSOCS. & ICF CONSULTING, supra note 54, at 2.
research for the civil aviation industry to encourage the industry to take action more quickly. In its 2004 report to the EPA, ICF Consulting recommended several items for the aviation industry to research further to determine the best plan of action.\textsuperscript{257} These items include researching the costs and benefits of various phase-out scenarios, the costs of the incentives and disincentives in the halon transition, the costs of local and global halon supplies over the next ten to twenty years, the current and projected overall U.S. market demand and civil aviation industry demand for halon, and the impact and potential cost savings from early implementation of halon alternatives.\textsuperscript{258} Depending on the analysis performed, the findings will more than likely show the industry members that the halon transition problem is not something to be ignored, and ignoring the problem is just as costly as addressing the problem.

The parties to the Montreal Protocol recognize the need for a global effort in addressing the issues involved with the transition away from halons. The parties have encouraged the technical advisors to the Montreal Protocol to work with the ICAO to create a plan of action for the civil aviation industry.\textsuperscript{259} The parties have agreed to an action plan, known as the Decision XV/11 action plan, which consists of four phases.\textsuperscript{260} In the first phase, the Halon Technical Options Committee (HTOC) under the UNEP must compile information on the global halon supply, halon costs, and current emissions rates, and present this information to the ICAO.\textsuperscript{261} The ICAO will then be responsible for distributing the information to its members.\textsuperscript{262} Using this data, the “ICAO will issue a State Letter to member States in 2006, inviting them to require the use of proven alternatives in new aircraft designs to the extent practicable.”\textsuperscript{263} The next phase entails making the halon transition a priority at the ICAO Assembly in 2007. At the assembly, the “ICAO Secretariat will introduce an ICAO/HTOC working paper on the subject of

\textsuperscript{257} Id. at 41.

\textsuperscript{258} Id.

\textsuperscript{259} Catchpole et al., supra note 4, at 29.


\textsuperscript{261} Catchpole et al., supra note 4, at 29; Cortina, supra note 260.

\textsuperscript{262} Catchpole et al., supra note 4, at 29; Cortina, supra note 260.

\textsuperscript{263} Catchpole et al., supra note 4, at 29.
phasing out halons."\textsuperscript{264} If the ICAO assembly approves the recommendations and action plan in the working paper, then the member States will be "required to implement halon alternatives for identified applications in new airframe designs first certified on or after January 1, 2009."\textsuperscript{265}

Therefore, the civil aviation industry may soon be required to transition away from halons in 2009. However, the civil aviation industry will need help to meet these deadlines. To assist in the process, the FAA should expedite the certification process for the alternative agents and the related applications.\textsuperscript{266} The FAA should especially focus on expediting the certification process for those agents shown by the test groups to provide a safety level that is equivalent to the halons currently in use.\textsuperscript{267}

A joint effort by all of the ICAO member States will be the most successful in responding to the barriers in the transition away from halons to other alternatives.\textsuperscript{268} This joint effort will also be a necessity if the industry is to meet the 2009 deadline. To meet this deadline, the industry members will have to make the transition process a priority. Additional testing needs to be performed on the various alternative agents. Moreover, airframe manufacturers should begin the qualification and certification procedures for the alternatives that have already met the MPS standards for any of the four applications. Essentially, any regulations passed to implement this deadline will help make the transition a priority and will force the airlines to invest in the alternative applications regardless of the impact on their bottom line.

IV. SUMMARY OF THE TRANSITION AWAY FROM HALONS FOR THE CIVIL AVIATION INDUSTRY

In response to the discovery of the hole in the ozone layer, the members of the United Nations Environment Programme implemented the Montreal Protocol on Substances that Deplete the Ozone Layer with the goal of eliminating the harmful effects of the ozone-depleting substances, such as halons, on the ozone. The Montreal Protocol began a global effort to phase out the production and consumption of ozone-depleting substances.

\textsuperscript{264} Id.
\textsuperscript{265} Id. at 30.
\textsuperscript{266} Hughes Assocs. & ICF Consulting, supra note 54, at 35–36.
\textsuperscript{267} Id.
\textsuperscript{268} Catchpole et al., supra note 4, at 6.
The Montreal Protocol required developed countries to ban halon production by January 1, 1994, and developing countries by January 1, 2010. In support of the Montreal Protocol, other agencies, including the EPA, implemented rules and regulations to enforce the restrictions implemented by the international agreement. To comply with these restrictions, halon users identified alternative agents to replace the halons in their fire extinguisher systems, used primarily for their superior fire suppression capabilities.

For the most part, halon users were able to make the transition away from halons; however, four industries, the military sector, the oil and gas production industry, the merchant marine community, and the civil aviation industry experienced greater difficulties in the transition process.\(^\text{269}\) At this point, the civil aviation industry remains furthest behind in the transition process, as it continues to rely heavily on halons in its existing and new aircraft models.\(^\text{270}\) Although the other three industries lagged behind the majority, they were able to make the transition more easily than the civil aviation industry for three main reasons. First, the merchant marine community was able to revert back to the carbon dioxide systems they previously used that were not banned by federal regulations.\(^\text{271}\) Second, the military sector and the oil and gas production industry did not have as great of weight, space, and cost penalties associated with the alternative agents as compared to the civil aviation industry.\(^\text{272}\) Third, the military sector invested a large amount of money in identifying alternatives, which enabled them to find an alternative with fewer cost penalties than expected.\(^\text{273}\)

The civil aviation industry faces technical, economic, and regulatory barriers in implementing alternative agents into its four fire suppression applications, which include the lavatory trash receptacle, handheld, cargo compartment, and engine nacelle extinguisher systems.\(^\text{274}\) The technical barriers include developing minimum performance standards and testing procedures for each of the applications as well as designing systems for the new alternative agents if necessary.\(^\text{275}\) While the technical barri-

\(^{269}\) See WICKHAM, supra note 57, at 11-12.

\(^{270}\) See id.

\(^{271}\) See supra text accompanying notes 231-36.

\(^{272}\) See supra text accompanying notes 226-30, 238-43.

\(^{273}\) See WICKHAM, supra note 57, at 11.

\(^{274}\) See supra text accompanying notes 154-60.

\(^{275}\) See supra text accompanying notes 158-71.
ers should be the easiest for the civil aviation industry to overcome, it has taken the industry longer than expected to develop the standards and procedures for each application, and only one application for one model aircraft currently has an alternative system in place. Furthermore, the aviation industry does not appear to be remotely close to installing an alternative system in any of the other applications. This is due to the significant weight, cost, and space penalties associated with the alternative agents and the cost-focus attitude of the aviation industry. The focus of the industry as a whole is to reduce costs; thus, implementing these alternative systems is not a priority and no regulation is currently forcing civil airlines to implement alternatives, or penalizing the industry for not implementing any alternatives.

Overall, there are three factors that impede the civil aviation industry's transition away from halon alternatives. The industry believes that the halon supply is sufficient to last at least ten years, no current regulations are forcing the issue on the financially unstable industry, and all of the alternative systems, except for the lavatory trash receptacle extinguisher, possess weight, cost, and space penalties. However, the civil aviation industry may soon have to change its priorities to respond to the ICAO's 2009 deadline. The FAA should focus on testing additional alternatives for each application to identify more acceptable agents for the industry, while the airframe manufacturers should begin procedures to certify systems using agents that already meet the MPS and testing procedures for each application. To make the civil aviation industry's transition away from halons successful, the industry as a whole, including the researchers, the FAA, the airframe manufacturers, the suppliers, and the airlines, must work together to make it a priority.

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276 Wickham, supra note 57, at 30.