Final Management Capstone Research Project Report/Paper:

The Boeing 737 MAX Case Study Analysis Report

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Management Capstone (BUS 5910)

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Unit 8 (Week 8) Written Assignment

August 13, 2019
The *Boeing 737 MAX* Case Study Analysis Report

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EXECUTIVE SUMMARY

Travel beyond bipedal and short automobile and/or metropolitan mass transit requires air travel for passengers that travel on vacation and/or professionally. The forecasted growth of global air travel is a compounding 3.5% increase in annual growth industry wide through 2037 according to I.A.T.A. (Garcia, 2018). Airline passenger traffic is expected to essentially double current frequency to 8.2 billion in 2037, according to Garcia (2018). The Boeing Company and Airbus Industries dominate the airline transport category aircraft development and production that supplies global airlines with their aircraft. Historically, The Boeing Company has set the “Gold Standards” in the airline transport category aircraft utilized in the global transport of people. The latest version of the long-standing, single aisle, Boeing 737 cash cow workhorse airline aircraft has been updated with enhanced efficiencies in the newest model in the product line, the Boeing 737 MAX. In 2018 two new Boeing 737 MAX 8 aircraft crashed sequentially, Lion Air Flight Number #610 and then Ethiopian Airlines Flight Number #301, in the very similar circumstances and very similar situations shortly after takeoff. The two crashed had zero survivors and three-hundred and forty-six (346) total fatalities. The unprecedented situation has resulted in the global grounding of the Boeing 737 MAX 8 and Boeing 737 MAX 9 aircraft. Flight data recorder, cockpit-voice recorders, radar, and satellite data analysis has led to the global conclusion and probable cause of both crashes being the new Boeing Maneuvering Characteristics Augmentation System (M.C.A.S.), which was added to the new Boeing 737 MAX aircraft brand line. The “Root” cause and problem of this Boeing 737 MAX case study is the M.C.A.S. In 2016, Boeing engineers identified a design flaw in the new Boeing 737 MAX wing that needed to be fixed. Attempts to aerodynamically modify the wing were unsuccessful. The M.C.A.S. was developed to ameliorate the flawed Boeing 737 MAX wing. The Boeing company is currently working with the United States (U.S.) Federal Aviation Administration (F.A.A.) to fix, update, and upgrade the software of the M.C.A.S. This report decisively disagrees with the current actions and strategies of The Boeing Company and the U.S. F.A.A. Herein, this report highly recommends completely redesigning the Boeing 737 MAX wing in its entirety to eliminate the need for the M.C.A.S. and also to proactively eliminate any further accumulation of M.C.A.S. problems and any and all potential “Unknowns.”
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Introduction

Modern global travel relies heavily on the transportation of human beings through aircraft. Typically transport category aircraft utilized by a multitude of global airlines is the primary mechanism of modern travel and transport for most people. The International Air Transport Association (I.A.T.A.), which represents 290 airlines (82% of global air traffic), reported that 4.1 billion passengers were transported system-wide (globally) in 2017, according to The International Air Transportation Association (2018).

The Boeing Company has been a historical and leading pioneer in developing and producing air transport category aircraft. Globally airlines have recognized and respected The Boeing Company as the pinnacle product in airline aircraft development, production, safety, and reliability.

Airbus Industries has developed become a worthy rival of The Boeing Company in recent decades. Airbus Industries dethroned The Boeing Companies’ legendary “Queen of the Skies” Boeing 747, with their significantly larger and technologically more advanced “Super Jumbo” Airbus A380 aircraft. The Airbus A380 aircraft typically seats 544 passengers comfortably in a four-class configuration, according to Airbus-a (2019).

The forecasted growth of global air travel is a compounding 3.5% increase in annual growth industry wide through 2037 according to I.A.T.A. (Garcia, 2018). Effectively enumerated, the number of airline passengers transported is forecasted to reach 8.2 billion in 2037, essentially being double that of 2018 airline passenger global traffic in 2018, according to Garcia (2018). Together both The Boeing Company and Airbus Industries dominate the development, production, supply, and sale of transport category aircraft for the global airline industry. The Boeing Company and Airbus Industries are fiercely competing to meet and command the needs of the forecast needs of the airline market, globally. Interestingly, it should be noted that global passenger airlines have discontinued the purchasing, and the usage in the U.S., of the Boeing “Jumbo” 747-400 “Queen of the Skies” and the Airbus “Super Jumbo” A380 aircraft. Global passenger airlines feel that less safe two engine smaller aircraft best fit their business models.
The Boeing Company Background Information

“Boeing is the world's largest aerospace company and leading manufacturer of commercial jetliners, defense, space and security systems, and service provider of aftermarket support,” according to Boeing-d (2019). The Boeing Company (Boeing) provides products and services to commercial and government organizations in 150 countries (Boeing-d, 2019). Currently, there are more than 10,000 Boeing produced jetliners in service globally (Boeing-d, 2019). The Chicago-based (United States of America, U.S.A.) Boeing is valued at approximately $101.1 billion United States Dollars (U.S.D.) and employs “roughly 150,000” world-wide, according to Boeing-e (2019).

William E. Boeing incorporated Pacific Aero Products on July 15, 1916, later renaming the to the Boeing Airplane Company on May 17, 1917 following the United States (U.S.) President Woodrow Wilson declared war on Germany on April 8, 1917, according to Boeing-g (2019). The Boeing Airplane Company was renamed The Boeing Company in 1961 in an effort to expand its market scope beyond that of airplanes (Britannica, 2019).

Boeing revolutionized global air travel for the masses with the development of the double decker “Jumbo Jet” Boeing 747 “Queen of the Skies.” The Boeing 747 provided the safety and power of four turbojet engines to make intercontinental travel attainable to the global population. The iconic Boeing 747 was developed and build in sixteen months by the Boeing “Incredibles” in 1969, according to Boeing-h (2019). The most
current version of the Boeing 747 in production is the Boeing 747-8. The Boeing 747-8 will serve as next U.S. Presidential Aircraft. Boeing has been awarded a $3.9 billion U.S.D. contract for two Boeing 747-8’s to be delivered by December 2024 and be painted “Red, White, and Blue,” according to Walsh, Alexander, Walcott, and Cooney (2018). Global airlines have been phasing out safe four engine “Jumbo” style aircraft from their operations. U.S. Airlines have discontinued all Boeing 747-400 passenger flight operations, while some international airlines still utilize the aircraft, according to Slotnick (2018). Moreover, Airbus Industries has ceased production of is “Super Jumbo” A380 aircraft committing to produce only the remaining firm orders for Emirates Airlines, which has singularly kept the A380 brand alive for several years, according to Schwartz (2019). While the A380 has never had a freighter version, the Boeing 747-8 freighter (B747-8F) version production has been saved by United Parcel Service (U.P.S.) placing an order for thirty-two (32) Boeing 747-8F aircraft and four (4) Boeing 767 freighters (B767F) to be fully delivered by 2021, according to UPS (2018).

The current brand lines of aircraft Boeing has in production includes the following: Boeing 737, Boeing 767, Boeing 777, Boeing 747-8, and the Boeing 787, according to Boeing-i (2019). The Boeing Business Jets (B.B.J.) brand line are the same fundamental aircraft sold to the airlines, which have been custom converted for to private jet owners. Boeing also offers freighter versions of all their current production aircraft.

Photograph Source:
https://www.boeing.com/resources/boeingdotcom/commercial/customers/ups/ups_747_8_order/ups_747_8_order_1500x400.jpg
U.S. F.A.A. Airline Transport Category Aircraft Certification Process

In order for any aircraft to fly it must be deemed airworthy by the appropriately delegated regulatory agency. In the U.S. the U.S. Federal Aviation Administration (F.A.A.) requires each and every aircraft to have a genuine airworthiness certificate physically present in the aircraft that is specific for that exact aircraft. The U.S. F.A.A. has been charged with all duties and competencies of the certification process by the U.S. Department Of Transportation (D.O.T.).

The purpose of the U.S. F.A.A. airworthiness certificate is proof that both critical and due diligence has been executed in the official certification of the aircraft. U.S. F.A.A. airworthiness certification effectively deems the aircraft is been designed, developed, constructed, and tested to critical and accountable standards that merit safe flight and operation(s).

The U.S. F.A.A. aircraft certification process includes the following:

I) “A review of any proposed designs and the methods that will be used to show that these designs and the overall airplane complies with FAA regulations;”
II) “Ground tests and flight tests to demonstrate that the airplane operates safely;”
III) “An evaluation of the airplane's required maintenance and operational suitability for introduction of the airplane into service; and”
IV) “Collaboration with other civil aviation authorities on their approval of the aircraft for import,” according to FAA-a (2019).

Once the U.S. F.A.A. approves and grants “Full-Certification” the aircraft producer may produce the aircraft to the exact approved criteria and standards, deliveries of the materialized aircraft products may commence.
The **Boeing 737 MAX** Case Description (Problem Statement and Case Elements)

The single-aisle **Boeing 737** line of products have been the “*Bread and Butter*” for **Boeing** and their global airline customers for decades. The **Boeing 737** aircraft the entry-level “*Gold Standard*” airline transport category aircraft for most airlines, excluding smaller regional “*Turbo-Prop Puddle Jumpers,*” and the recently founded “*Regional Jets.*” The **Boeing 737** is “*The World’s Most Popular Jet*” and range in average list prices from $89.1 million United States Dollar (U.S.$) for the **Boeing 737-700 Next Generation (N.G.)** version to $134.9 million (U.S.$) for the new *state-of-the-art Boeing 737 MAX 10*, according to Boeing-a (2019). The historical safety record of the **Boeing 737** brand is unmatched.

The newest version of the **Boeing 737**, the **Boeing 737 MAX**, first flew on January 30, 2016, according to Boeing-b (2019). Variants of the **Boeing 737 MAX** include the following: 737 MAX 7, 737 MAX 8, 737 MAX 200, 737 MAX 9, and 737 MAX 10 (Boeing-a, 2019). “The 737 MAX is the fastest-selling airplane in Boeing history with about 5,000 orders from more than 100 customers worldwide” (Boeing-c, 2019).

The new **Boeing 737 MAX** has had two catastrophic crashes that have killed all occupants of both flights, resulting in a combined three hundred and forty-six (346) human fatalities. The sequential crashing of two new airline transport category aircraft under very similar circumstances is unprecedent for **The Boeing Company**, the airline industry, and traveling public.
The first crash was Indonesians’ *Lion Air* Flight Number #610 (*Boeing 737 MAX 8*) “went down at around 6:30 am local time Monday, enroute from Jakarta to Pangkal Pinang,” killing all 189 people (souls) (including three children), according to Griffiths, George, and Quiano (2018). The second crash was *Ethiopian Airlines* Flight Number #302 (*Boeing 737 MAX 8*). “The plane, en route to Nairobi, Kenya, lost contact at 8:44 a.m. local time, six minutes after taking off from Bole International Airport in the Ethiopian capital,” killing all 157 people (souls), according to Kriel and John (2019).

Nearly immediately following the second crash of the *Boeing 737 MAX 8*, global airlines, excluding those under the regulatory authority of the United States (*U.S.*) Federal Aviation Administration (*F.A.A.*), voluntarily grounded all their *Boeing 737 MAX* aircraft and ceased all associated flight operations indefinitely. The media, political, and travel passenger pressure began to accumulate rapidly for the
U.S. F.A.A. to ground the Boeing 737 MAX aircraft. The U.S. F.A.A. refused to ground the Boeing 737 MAX aircraft, while reiterating the safety of the aircraft and its self-governing regulatory authority practices. Ultimately, the President of the United States Donald J. Trump order the grounding of the U.S. associated Boeing 737 MAX aircraft on March 13, 2019, according to Liptak (2019). U.S. Airlines flying the Boeing 737 MAX 8 and Boeing MAX 9 aircraft included: United Airlines, American Airlines, Southwest Airlines, and Alaska Airlines, according to Gilbertson (2019). No Boeing 737 MAX planes have been flown since, with exception to U.S. F.A.A. approved essential non-revenue aircraft repositioning flights for storage by the owning airlines.

The definitively exact causes of the two Boeing 737 MAX 8 crashes has not been determined. However, both crashes occurred under very similar conditions, circumstances, and aircraft behavior based on the aircraft flight data recorder data and early crash analysis by government investigators.

Not knowing the exact definitive cause of these crashes is very unsettling. Investigations by the media, organizations, The Boeing Company, and other entities has revealed and illuminated the most probable cause of the crashes is Boeing’s new Maneuvering Characteristics Augmentation System (M.C.A.S.) that was added to the new Boeing 737 MAX’s. Early on after the second crash The Boeing Company was publicly proposing a M.C.A.S. software update would fix the problem quickly and get the Boeing 737 MAX’s airborne shortly, presumably in the matter of a couple of weeks. The Airline Pilots Association, International (A.L.P.A.) airline pilot representatives and major U.S. airline pilot unions were
shocked, appalled, and extremely upset The Boeing Company did not notify and/or disclose to the airlines and/or the pilots that the new M.C.A.S. flight control safety systems were “On-Board” the aircraft. Moreover, not training and/or flight manuals in the procession of the airlines acknowledged the existence of the M.C.A.S. on the new Boeing 737 MAX aircraft. Boeing recommended to the airlines that pilots be trained with a briefly between fifty-six minutes and three hours in a self-administered online (e.g. iPad) training program, which did not present any information on the new M.C.A.S. to the Southwest Airline and American Airline pilots, according to Liebermann (2019). Moreover, the U.S. F.A.A., whom has ultimate regulatory authority in new aircraft certification and airworthiness under the U.S. Department Of Transportation (D.O.T.), essentially gave self-certification and regulatory authority to The Boeing Company for certain systems including the new M.C.A.S.
Identification of Case Stakeholders

A stakeholder is defined as “one that has a stake in an enterprise,” or “one who is involved in or affected by a course of action,” according to Merriam-Webster-a (2019). Stakeholders in this Boeing 737 MAX case study include the following: 1) Travelers that utilize the Boeing 737 MAX, 2) The Boeing Company (Boeing), 3) Airlines that have taken deliveries and/or order for the Boeing 737 MAX, 4) The Boeing 737 MAX engine manufacturer CFM, 5) Boeing 737 MAX parts and consumable supplies suppliers, and 6) Insurance companies insuring the Boeing 737 MAX in any way shape and/or form.

The Boeing Company Stakeholders: 1) The Boeing Chairman, President, and Chief Executive Officer (C.E.O.) Dennis A. Muilenburg is in full command of Boeing with oversight of the Board Of Directors (B.O.D.), 2) Board of Directors (B.O.D.), 3) Boeing Stockholders, 4) Boeing employees (Executives, Managers, Engineers, Assemblers, Operators, etc.), 5) Boeing sub-contractors (e.g. parts suppliers, etc.), and 6) Boeing insurers (e.g. insurance companies that Boeing pays for policies that can cover design and manufacturing liabilities, legal and crisis intervention, etc.).

Boeing Parts Supplier Stakeholders: Boeing does not make the Boeing 737 MAX from raw materials. The parts Boeing orders from is suppliers are also stakeholders in the Boeing 737 MAX problem.

Airlines Stakeholders: Any airline that has taken delivery of and/or placed an order for one or more Boeing 737 MAX aircraft (e.g. United Airlines, American Airlines, Southwest Airlines, Alaska Airlines, etc.). Airline sub-stakeholders include: 1) Passengers, 2) Employees, 3) Stockholders, 4) Sub-contractors (fueling, maintenance, ground services, etc.), and 5) Insurers (e.g. Insurance policy backers for airline crashes, lawsuits, etc.).

Boeing Parts Supplier Stakeholders: Boeing parts suppliers are feeling the problems of the Boeing 737 MAX now. Spirit Aerosystems Holding Inc. is the largest supplier for Boeing Co’s 737 MAX,
according to Johnsson (2019). “Spirit AeroSystems Holdings Inc. is rushing to preserve cash, manage a mountain of inventory and shield its workforce from layoffs” (Johnsson, 2019).

**Airline Passengers and Related Family Stakeholders:** Any passenger and/or pilots and/or flight crew and/or U.S. Air Marshall’s are categorized as safety stakeholders.

**Boeing 737 MAX Engine Manufacture Stakeholder:** The Boeing 737 MAX propulsion, or engines, is provided by LEAP-1 engines produced by CFM. CFM is a equal (50/50) joint company of General Electric (G.E.) and Safran Aircraft Engines of France, according to CFM (2019).

**U.S. F.A.A.:** The F.A.A. is charged with the overall safety of flight operations and aircraft certification by the U.S. D.O.T. Therefore, F.A.A. is obviously and inherently as significant stakeholder in the Boeing 737 MAX.
Potential liabilities and/or Risks for Case Stakeholders

The Boeing Company Stakeholders: 1) The Boeing Chairman, President, and Chief Executive Officer (C.E.O.) Dennis A. Muilenburg could potentially be fired for his position for his handling of the Boeing 737 MAX case by the board of directors. Both Mr. Muilenburg and the B.O.D. answer to all the stakeholders and the powerful stockholders. Alternatively, Mr. Muilenburg may be removed in countless ways for his handling of the Boeing 737 MAX case. The B.O.D. members may also be removed, or ousted, from their positions. The Boeing Stockholders can take significant and/or total losses on their financial investments. The Boeing 737 MAX case can affect the job stability and fruitfulness of the Boeing employees (Executives, Managers, Engineers, Assemblers, Operators, etc.), either directly and/or indirectly. For example, the production line for the Boeing 737 MAX has been suspended while the aircraft is grounded. Boeing sub-contractors (e.g. parts suppliers, etc.) will being taking a financial hit as parts that arrive “Just In Time” will not as long as the Boeing 737 MAX production line is suspended. Boeing insurers (e.g. insurance companies that Boeing pays for policies that can cover design and manufacturing liabilities, legal and crisis intervention, etc.) should be very concerned as law suite “Pile Up” and “Accumulate.”

Airlines Stakeholders: Airline passengers are primarily concerned about their own physical safety but also, in the event they die in a Boeing 737 MAX crash how it will affect their families financially, spiritually, and personally. Airline employees are most likely loosing work and pay while the Boeing 737 MAX is grounded. Unless, the Airlines are thoughtful, considerate, and generous enough to reassign, or realign, those affected employees without any financial penalties and/or punishments. Airlines are in the businesses to make a profit and that is the motive of the stockholders. If stockholders lose respect, confidence, faith, and hope in their airline, it’s a high probability those stockholders will sell their stock resulting a potential plummeting and crash of the stock value. Airline sub-contractors (fueling, maintenance, ground services, etc.) that route their services to the Boeing 737 MAX will likely see a downturn in revenue, with subsequent financial stability problems if the company is not financially
sound. Insurers (e.g. Insurance policy backers for airline crashes, lawsuits, etc.) of the airlines flying the Boeing 737 MAX may want to reevaluate their policies and offer to provide those airlines with specific policies for that aircraft, in order to lessen the footprint of damage with the dynamic policy costs.

Airline Passengers and Related Family Stakeholders: Any passenger and/or pilots and/or flight crew and/or U.S. Air Marshall’s will want to have absolute confidence in the aircraft prior to stepping on board a Boeing 737 MAX again.

Boeing 737 MAX Engine Manufacture Stakeholder: CFM will likely be affected by the production suspension of the Boeing 737 MAX, with the “Just In Time” philosophy and protocol. Boeing may not want to expend its finances and/or resources to accumulate and house the CFM LEAP-1 engines while the Boeing 737 MAX production line is suspended. CFM may need to layoff and/or furlough employees if it hasn’t already.

U.S. F.A.A.: The F.A.A. is charged with the overall safety of flight operations and aircraft certification by the U.S. D.O.T. The reputation, funding, organizational structure, and leadership are at risk and liable for its handling of the Boeing 737 MAX certification and the operational regulatory requirements of the Boeing 737 MAX.
The Boeing Maneuvering Characteristics Augmentation System (M.C.A.S.) (Case Elements)

The global international consensus of the two Boeing 737 MAX crashes is both aircraft had very similar flight path patterns. At this point in the investigations it is assumed that the flight crew (pilots) were not able to regain positive control of the aircraft prior to water or ground impact. The presumptive initial cause and sustained cause of the pilot loss of positive flight control is the newly implemented Maneuvering Characteristics Augmentation System (M.C.A.S.) in the Boeing 737 MAX brand. Preliminary flight data recorder and cockpit voice recorder analysis suggests this may be the case. However, the definitive cause of the crashes has yet to be determined and announced publicly.

The new CFM LEAP-1B engines provide a significant boost in propulsion to the Boeing 737 MAX that significant lift and the resulting nose-up pitch can result in the aircraft stalling. Stalling happens when smooth non-turbulent airflow over the wings is effectively lost, when the critical Angle Of Attack (A.O.A.) is reached. The A.O.A. is essentially the angle between the reference line of the aircraft (e.g. line from the tail to the nose) and the relative wind, or oncoming air. The critical A.O.A. of an aircraft wing airfoil can be achieved at any airspeed. Most airline transport category aircraft, including the Boeing 737 MAX, have two independent A.O.A. sensors loaded at opposite sides of the aircraft underneath the cockpit windows. The A.O.A. sensors have a range of rotation with a protruding “vane”, or mini-wing, that collects airflow data as the aircraft flies (Figure 1). The A.O.A. provide raw data for the calculation of the actual real-time A.O.A. of the aircraft at any given time, in any flight scenario and/or aircraft attitude.

**Figure 1** Angle Of Attack (A.O.A.) Sensor and “Vane”

(Illustration Source: Abend [2019]).
The new enhanced propulsion of the Boeing 737 MAX through the can make the aircraft nose attitude pitch up and thus stall faster and easier. This is Boeing’s motive for installing the new M.C.A.S. “To compensate and prevent a stall, Boeing designed the MCAS system, which automatically reduces the angle of attack by lowing the nose,” according to Abend (2019). The purpose of the M.C.A.S. is to provide an automated system to assist the pilots in preventing a dangerous stall flight scenario. “The Maneuvering Characteristics Augmentation System (MCAS) flight control law was designed and certified for the 737 MAX to enhance the pitch stability of the airplane – so that it feels and flies like other 737s,” according to Boeing-j (2019). “MCAS is designed to activate in manual flight, with the airplane’s flaps up, at an elevated Angle of Attack (AOA)” (Boeing-j, 2019). M.C.A.S. will only activate while the pilots manually fly the aircraft in a flaps-up flight configuration (Abend, 2019). Abend (2019) further explains, the automatic flight control systems, or autopilot, will not allow to the aircraft to exceed its safe flight envelope thereby M.C.A.S. is irrelevant unless the pilots are manually flying in a flaps-up flight configuration. “A sensor within the angle of attack vane on either side of the fuselage sends a signal to the MCAS, which in turn automatically moves the horizontal stabilizer to pitch the nose down,” according to end (2019). Only one signal from either A.O.A. sensor is required to activate M.C.A.S. (Abend, 2019).
“MCAS is designed to activate in manual flight, with the airplane’s flaps up, at an elevated Angle of Attack (AOA),” according to Boeing-f (2019).
Critical Analysis of the Boeing 737 MAX M.C.A.S. Problem (Case Elements)

The international consensus that the “Root” cause of both the Lion Air Flight Number #610 and Ethiopian Airlines Flight Number #302 crashes was due to the new Boeing 737 MAX M.C.A.S. system.

Following the crash of Lion Air Flight Number #610 the U.S. F.A.A. issued an Emergency Airworthiness Directive (A.D.) in which Boeing and all Boeing 737 MAX - 8 and Boeing 737 MAX - 9 owners and operators must comply with a regulatory level, specifically F.A.A. (A.D.) # 2018-23-51, dated November 7, 2018 (FAA-b, 2018). The owners and operators of F.A.A. (A.D.) # 2018-23-51 had three days, or 72 hours, to comply by updating the Boeing 737 MAX aircraft certification limitations and operating procedures within the Airplane Flight Manual (A.F.M.) to include “Runaway Stabilizer,” according to FAA-b (2018). The F.A.A. (A.D.) # 2018-23-51 was triggered and prompted by the fact that Lion Air Flight Number #610 crash investigators determined Boeing 737 MAX A.O.A. sensors are capable of generating erroneous inputs, potentially making the aircraft difficult for pilots to control, according to Bellamy III (2018).

Pilots of the Boeing 737 MAX have two steps to regain control of the aircraft in a loss of positive flight control scenario. The first step for the commanding pilot is the “Runaway Stabilizer Trim” procedure dating back to the Boeing 707 (1950’s), according to Abend (2019). The second setup is to pull the circuit breaker for the M.C.A.S. (Abend, 2019). These two budget fixes have been proposed by Boeing and addressed by the F.A.A. in A.D. # 2018-23-5.

Both Lion Air Flight Number #610 and Ethiopian Airlines Flight Number #302 M.C.A.S. activation being triggered by erroneous A.O.A. sensor signals, according to Abend (2019). “Accidents typically have more than one factor contributing to their probable cause” (Abend, 2019). In response to the identification of the Boeing 737 MAX A.O.A. erroneous sensors readings, “Boeing has developed an MCAS software update to provide additional layers of protection if the AOA sensors provide erroneous data,” according to Boeing-j (2019).
Boeing has continually publicly pitched and publicly campaigned the M.C.A.S. problem is solely software based, going on to push that the Boeing 737 MAX aircraft will be in the air and operational shortly, presumably in the matter of weeks. Following the global grounding of the Boeing 737 MAX, Boeing has begun to take the problem seriously and begun to cooperate with domestic and international regulatory bodies, organizations, and entities in a genuinely motivated and proactive manner. “Experts from nine civil aviation authorities have confirmed they will participate in the Boeing 737 MAX Joint Authorities Technical Review (JATR) that the FAA established earlier this month,” according to FAA-c (2019). “The JATR team will conduct a comprehensive review of the certification of the aircraft’s automated flight control system” (FAA-c, 2019).

Boeing has greatly decreased the production of the Boeing 737 MAX, shortly after the global grounding of the aircraft, and cannot deliver newly produced aircraft to its customers, according to Bogaisky (2019). The production of Boeing 737 MAX continues and Boeing is running out of storage space for the newly produced aircraft, according to Zhang (2019). The airlines currently operating the Boeing 737 MAX and those airlines with “Firm” order must be shocked and very apprehensive. Boeing has been very aggressive with its software fix strategy with rigorous and full spectrum industry and regulatory testing of the software updates in High-Fidelity Level-D full motion flight simulators at the controls of F.A.A. test pilot engineers by attempting to break the chain of events in the Boeing 737 MAX M.C.A.S. by “developing a software fix that would limit the potency of that stabilization system,” according to Prokupecz, Griffin, and Wallace (2019).

The Boeing 737 MAX M.C.A.S. problems have begun to steadily accumulate. In addition to the M.C.A.S. software problem of not being able to accurately interpret and respond to A.O.A. sensor signals, additional faults in the M.C.A.S. system have been illuminated. The most current software fixes have again failed rigorous High-Fidelity Level-D flight simulation testing by the F.A.A., according to Prokupecz, et al. (2019). “In simulator tests, government pilots discovered that a microprocessor failure could push the nose of the plane to the ground. It is not known whether the microprocessor played a role
in the crashes” Prokupecz, et al. (2019). Prokupecz, et al. (2019) go on to mentioned in interrogating the potential microprocessor failure pilots “it was difficult for the test pilots to recover in a matter of seconds,” one source said (Prokupecz, et al. (2019). “And if you can’t recover in a matter of seconds, that’s an unreasonable risk” Prokupecz, et al. (2019). Boeing engineers are now trying to address the issue, according to Prokupecz, et al. (2019). The microprocessor may need to be completely redesigned and reengineered so that it will align and dynamically interact with the M.C.A.S. Alternatively, the software for the M.C.A.S. could be completely recoded once the M.C.A.S. microprocessor is produced, tested, and validated.

Captain Les Abend is a career airline pilot with over thirty years of flying for the airlines and recently retiring from a long run as a Captain for a Boeing 777 for his favorite, American Airlines. Captain Les Abed has been a contributing author for the very well renown FLYING magazine writing his own column for approximately fifteen years and additionally become a consulting airline expert for various news outlets. Captain Les Abed vocalizes his concerns of Boeing not informing the airline customers and/or the pilots of the existence of the M.C.A.S. on the new Boeing 737 MAX as “disturbing to me, and quite frankly, indefensible” (Abend, 2019). Captain Abend goes on to state “Perhaps Boeing should consider that the 737 has been stretched beyond safe limits” (Abend, 2019). Abend (2019), goes on to discuss the multi-dimensional financial implications and “ripple” affects the Boeing 737 MAX is causing in the global economy, exclusive of civil and potential criminal litigation, that will continue for years to come “stemming from the accidents.”

The U.S. F.A.A. has essentially and effectively allowed Boeing to Self-Certify its new M.C.A.S. system on the Boeing 737 MAX. The various media outlets and investigational journalism has suggested this may be political effects of the President Trumps’ administration. Expeditious hearing on that matter found no one at fault. Regardless the cause, the effects are indelible. Abend (2019) mentions typically Boeing systems will frequently have three and sometimes four redundant systems. This philosophy has led to an unmatched U.S. airline safety record. However, the new Boeing M.C.A.S. system is faulty and
has no backup, not to mention tertiary or quantinary backups system, as Abend (2019) points out. Captain Abend is mystified by the Boeing’s philosophy departure on the M.C.A.S. and illuminating that the scariest problem may be that M.C.A.S. itself is not understood by Boeing (Abend, 2019).
Governance and Financial Analysis of the *Boeing 737 MAX* Problem

*Boeing* and the top *Boeing* organizational leadership structure is commanded by the *Chairman*, *President*, and Chief Executive Officer (*C.E.O.*) Dennis A. Muilenburg (*Boeing*-d, 2019). “Muilenburg became chairman of the board in March 2016, chief executive officer in July 2015 and president in December 2013,” according to *Boeing*-e (2019). Mr. Muilenburg is assisted by a fifteen-member *Executive Council* (*Boeing*-d, 2019). “The Boeing Company's business is conducted by its employees, managers and corporate officers led by the chief executive officer, with oversight from the Board of Directors,” according to *Boeing*-f (2019). *Boeing* corporate governance principles and current practices are periodically reviewed by the “Board’s Governance, Organization and Nominating Committee” (*Boeing*-f, 2019).

*Boeing* is financially stable and financially sound with a total 5,764 unfilled orders for their commercial airline transport category aircraft, according to *Boeing*-j (2019). Adjusting for the new *Boeing* adopted revenue recognition accounting standard (ASC 606) there are 5,546 unfilled orders (*Boeing*-j, 2019). *Boeing* backlogged orders, adjusted for ASC 606, include the following: *Boeing* 737 (4,425), *Boeing* 747-8 (21), *Boeing* 767 (97), *Boeing* 777 (430), and *Boeing* 787 (573), according to *Boeing*-j (2019).

Obviously, *Boeing* has started to feel the financial pressure of the self-inflicted problem(s) and wounds. The inability to deliver newly produced *Boeing 737 MAX*’s to customers and not getting paid for their work and resource input must be frustrating for *Boeing*. Boeing has ramped down their production of the *Boeing 737 MAX*, yet is running out of places to store the newly produced faulty jets. The fact that *Boeing* continues to produce a faulty get tells a lot about *Boeing’s* philosophy, attitude, and leadership. At the latest annual stock holders meeting *Boeing C.E.O*. Dennis A. Muilenburg valiantly and vigorously reassured *Boeing* stock shareholders that that *Boeing “owns” some responsibility for improving the safety of the *Boeing 737 MAX*, while not acknowledging any design flaws in the aircraft to a fifty-percent full auditorium on April 28, 2019, according to MacMillian (2019). *Boeing C.E.O*. Dennis A. Muilenburg is
also the chairman of the Board of Directors (B.O.D.). Thus, C.E.O. Dennis A. Muilenburg has supreme and uncontested authority in the commanding The Boeing Company.

While at the annual Boeing stock shareholders meeting, shareholders tried to pass by vote on a proposal that would separate the Chairmanship of the B.O.D. and the C.E.O. roles and positions. The vote on the proposal failed with only thirty-four percent of the shareholders voting in favor of the proposal, according to Matousek (2019). Voters argued credible oversight of the company was compromised in the current leadership situation (Matousek, 2019).

Boeing did get an infusion of confidence with a reassuring recent order for two hundred (200) Boeing 737 MAX’s from the parent company of British Airways, International Consolidated Airlines Group (I.A.G.) on June 18, 2019 at the world renown Parish Airshow, according to Josephs (2019). Boeing stocks immediately responded with a surged 5.4% increase (Josesph-a, 2019). The recently identified additionally flaw on June 26, 2019 made Boeing stocks tumble down 1.33% (-1.33%), according to Levin, Johnsson, and Jasper (2019). Moreover, “The FAA recently found a potential risk that Boeing must mitigate,” the agency said in an emailed statement Wednesday that didn’t provide specifics (Levin, et al, 2019).

Boeing did take another potent “Hit,” or “Blow,” on July 7, 2019 when, when Saudi Arabia’s flyadeal airlines canceled a $6 Billion U.S.D. order for Boeing 737 MAX and opted to order the new high efficiently next-generation Airbus A320neo jet powered by the CFL LEAP-1A engines. Credit scores ratings for The Boeing Company with Flitch Ratings and Moody’s Investor Services have been upheld, yet the decreased their forecast outlook with a negative note, according to Josephs-b (2019). Earnings for the first fiscal quarter of the Boeing 737 MAX grounding resulted in a huger $5.6 Billion U.S.D. accounting charge, according to Boeing-m (2019). The Boeing Company has Eaten a $3.6 Billion U.S.D. (G.A.A.P.) loss (Q2-2019) due to the grounding of the Boeing 737 MAX (Boeing-m, 2019). The loss is the largest quarterly loss ever in the history of The Boeing Company, according to Boeing-m (2019).
The continued accumulated problems (technical, engineering, and financial) resulting from the Boeing 737 MAX debacle will continue. The absolute lack of any meaningful responsibility, accountability, oversight, and governance by the Boeing Company in response to the Boeing 737 MAX crashes brings into question the integrity and competency of the current Boeing Company leadership regime. Moreover, the “Rogue” departure of traditional Boeing and airline transport category aircraft design philosophy, quality and validity credibility, and independent certification and oversight with the new Boeing M.C.A.S. system is beyond disturbing. Moreover, it highlights a systemic, enterprise-wide, organizational flaw in its theories and good practices. The credibility, respect, and safety reputation and confidence of both the U.S. F.A.A. and the Boeing Company have been shattered with their behavior, decisions, actions, and their knowing and willful intent (Abend, 2019).
Possible Solutions (Possible Alternatives) for the Boeing 737 MAX

The “Root” cause of the Boeing 737 MAX debacle is the M.C.A.S. I offer four possible solutions offerings for The Boeing Company to rectify the Boeing 737 MAX M.C.A.S. problem. The first possible solution is to discontinue production of the Boeing 737 MAX and terminate the Boeing 737 MAX program. The second is to Re-Design and Re-Engineer the Boeing 737 MAX wing to eliminate the need for M.C.A.S. The third is to Expropriate and completely remove the current M.C.A.S. and re-design and re-engineer the M.C.A.S. on a “Clean Sheet,” or from scratch or anew. Followed by an unrestricted and unrestrained flight testing “simulator and actual in-flight” by Boeing test pilots to test any conceivable and/or possible failure of the re-designed and re-engineered M.C.A.S. The fourth solution is to update M.C.A.S. by adding the “G-Force” trigger for the M.C.A.S. software and update M.C.A.S. software to be fully functional with input from two independent Angle of Attack (A.O.A.) indicators and G-Force sensor meter. Add second, third, and forth level backups to M.C.A.S.

Solution #1: Discontinue production of the Boeing 737 MAX and terminate the Boeing 737 MAX program.

Discontinuation of the production of the Boeing 737 MAX and subsequent program termination will result in the eliminating the revenue of 4,415 aircraft backorders in the production line queue, along with any potential future orders, according to Boeing-k (2019). Moreover, once Boeing 737 MAX aircraft production is discontinued The Boeing Company will be required to return all production line and order financial down payments and financial deposits to the appropriate contracted customers. These customer stakeholders will be both devastated and righteously revolted in their acknowledgment and acceptance of the discontinuation of the Boeing 737 MAX and their binding contractual orders. The Renton, Washington (United States of America, U.S.A.) production plant will most likely and predictably will have permanent employee layoffs in result to this decision and solution. Dennis Muilenburg, the Boeing Chief Executive Officer (C.E.O.), President, and Chairman of the Board of Directors (B.O.D.), stated that the “best estimate” of a safe return of the Boeing 737 MAX would be in October 2019, according to Gates (2019). “A slip in that optimistic timeline could mean the Renton 737 production line would be temporarily shut
down” (Gates, 2019). “That’s not something we want to do, but something we have to prepare for,” Dennis Muilenburg said on Boeing’s second-quarter earnings call with analysts and the press, according to Gates (2019). Gates (2019), goes on to state the halt to Boeing 737 MAX production at the Boeing Renton plant would mean temporary layoffs for the plants more than 10,000 employees.

Financially, simply discontinuing the Boeing 737 MAX production and terminating the program would most likely result in survival for Boeing and the majority of its stakeholders, due to the companies dense and vast structure and holdings. According to Boeing-b (2019), the average list price of a Boeing 737 MAX is $121.98 million United States Dollars (U.S.D.). Discontinuing the Boeing 737 MAX production would immediately result in the forfeiture of $538.54170 million U.S.D., or 0.538 billion U.S.D., in lost revenue, not accounting for contractual pricing discounts, for its backlog of 4,415 Boeing 737 MAX orders. Boeing has now quantified and publicly released the first complete financial quarter loss of $5.6 Billion United States Dollars (U.S.D.) accounting charge to the global Boeing 737 MAX grounding, according to Boeing-c (2019). Moreover, the largest financial quarter loss of revenue in The Boeing Company history to be $3.380 Billion U.S.D. utilizing Generally Accepted Accounting Principles (G.A.A.P.) calculations (Boeing-l, 2019).

No further production of the Boeing 737 MAX would result in the immediate and synchronous discontinuation of employment for all associated production employees at the Boeing Renton Washington plant. Moreover, the reputational damage of Boeing and its stakeholders would be permanently damaged in a grossly and obvious visible way. Specifically, the long-standing pinnacle reputation of Boeing in the industry could be shattered. Together, I would assume this proposed solution of discontinuing the Boeing 737 MAX production and terminating the product line (brand) is unacceptable to most if not all stakeholders and thus is not a viable alternative solution. However, the decision on this alternative solution is ultimately up to the Boeing Chief, Dennis Muilenburg.
Solution #2: Re-Design and Re-Engineer the Boeing 737 MAX wing to eliminate the need for M.C.A.S.

The genesis of the “Root” problem of the Boeing 737 MAX in the M.C.A.S. system is based solely on a faulty and compromised wing design, according to Gates and Baker (2019). The wing inherently is unstable and uncontrollable in extreme maneuver flight conditions. More specifically and targeted “a clear issue to address” with respect to the aircraft’s aerodynamic handling of extreme maneuvers was identified in wind tunnel testing in 2012 an anonymous Boeing Engineer stated, according to Gates and Baker (2019). Boeing tried unsuccessfully to significantly attenuate the problem with more design modifications to the wing (Gates & Baker, 2019).

Under the continuing Boeing 737 MAX crisis most likely will provide sufficient motivation and resources to redesign the Boeing 737 MAX wing to eliminate the problem entirely from the aircraft. To date Boeing championed M.C.A.S. has failed resulting in 346 fatalities globally with the daunting financial consequences are just beginning to be materialized, monetized, visualized and comprehended.

*The Boeing Company* has known the design flaw with the wing needed to be corrected since 2012, according to Gates and Baker (2019). The global consensus and interpretation of the data retrieved from the two Boeing 737 MAX crashes has led to M.C.A.S. as the probable cause in both crashes. The M.C.A.S. itself currently is a failed fix for the flawed wing design of the Boeing 737 MAX. Therefore, I strongly feel the proposed solution (alternative) to re-design and re-engineer the Boeing 737 MAX wing is both a credible, viable, and promising course of action.

Solution #3: Update M.C.A.S. by adding the “G-Force” trigger for the M.C.A.S. software and update M.C.A.S. software to be fully functional with input from two independent Angle of Attack (A.O.A.) indicators and G-Force sensor meter.

The “Root” problem with the Boeing 737 MAX is the M.C.A.S., which is a microprocessor and software fix for the flawed wing design. Boeing could provide the minimal required software updates, microprocessor re-design/re-engineered, and addition of the “G-Force” trigger for an updated M.C.A.S.
The initial design of the M.C.A.S. intended for both independent Angle of Attack (A.O.A.) indicators and G-Force sensor meter all to be participating and collectively agree to trigger the M.C.A.S., according to Gates and Baker (2019). However, as the design of the M.C.A.S. progressed and evolved, Boeing sequentially removed the G-Force sensor and second A.O.A. indicator concurrence trigger requirements (Gates & Baker, 2019). Effectively, Boeing decided to dilute and/or attenuate (lessen) the M.C.A.S. trigger control criteria.

Boeing could solve the current and apparent M.C.A.S. problem by reinstituting its original M.C.A.S. design that requires a G-Force meter and second A.O.A. indicator concurrence trigger requirements, along with a functional software system. However, the potential for future disasters and fatalities still looms with the flawed Boeing 737 MAX wing design.

Solution #4: Expropriate and completely remove the current M.C.A.S. and re-design and re-engineer the M.C.A.S. on a “Clean Sheet,” or from scratch or anew.

The strategy to reverse engineer, based on the original design criteria of M.C.A.S., and/or update and patch the M.C.A.S. is in itself flawed. First, the putting a Band Aid® on top of another Band Aid® approach and strategy is poor, lazy, and undisciplined. If Boeing is truly unwilling and/or unable to rebuild and redesign the wing of the Boeing 737 MAX, then the M.C.A.S. should be completely removed from the aircraft, or expropriated, until a viable, credible, and suitable replacement can be deployed. The U.S. F.A.A. stakeholder will need to be consulted to determine what additional design and/or operational criteria the Boeing 737 MAX will require to come airborne, while the M.C.A.S. is being redesigned from scratch.

It is possible the Boeing 737 MAX can operate safely with “hard set,” set by aircraft maintenance personnel, with “De-Rated” engine power. De-Rated engine power is routinely utilized in airline operations. This de-rated takeoff thrust is used to minimize the takeoff noise footprint and decrease operational costs with lower fuel, Jet-A, consumption. The Boeing 737 MAX should have its M.C.A.S.
disabled and be completely removed from the aircraft. The *U.S. F.A.A.* would need to be in the same book, on the same page, and preferably on the same word in a mutually beneficially interaction to achieve this objective, or the deliverable of getting the *Boeing 737 MAX* back up in the air operationally in an all-inclusive global scope.

Once the *Boeing 737 MAX* is operationally back up in the air without the *M.C.A.S.*, sufficient pressure, or heat, will be removed from *Boeing* to design a viable, credible, and safe *M.C.A.S.* However, and again, the potential for future disasters and fatalities still looms with the flawed *Boeing 737 MAX* wing design. This solution would provide some comfort and reassurance to the *Boeing* stakeholders.
**Recommended Plan of Action for the Boeing 737 MAX**

I highly recommend that *The Boeing Company* re-design and re-engineer the *Boeing 737 MAX* wing to eliminate the need for the *M.C.A.S.* (proposed solution #2). The central flaw of the *Boeing 737 MAX* *M.C.A.S.* rooted problem is the flawed design of the wing *The Boeing 737 MAX* wing design flaw was initially identified by *Boeing 737 MAX* engineers in wind tunnel testing in 2012, according to Gates and Baker (2019). The *M.C.A.S.* was designed and implemented in an attempt to negate this design flaw.

The *M.C.A.S.* has failed in the unforgiving global operations arena and environment resulting in a combined 346 fatalities from the two crashes of *Lion Air* Flight Number #610 (*Boeing 737 MAX 8*) and *Ethiopian Airlines* Flight Number #301 (*Boeing 737 MAX 8*). There were no survivors in either crash. Both crashes are currently under investigation with the definitive cause(s) of the crashes, yet to be determined. However, according to data from the black boxes and cockpit voice recorders indicate both crashes occurred under similar circumstances. The global consensus of investigators, regulators, and experts have pointed to the *M.C.A.S.* as the primary cause of both crashes.

*The Boeing Company* has known since 2012 that the *Boeing 737 MAX* wing has the inherent design flaw (Gates & Baker, 2019). Essentially, *Boeing* “produced a dynamically unstable airframe the 737 MAX” and “tried to mask the instability with software,” according to Travis (2019). Recent *M.C.A.S.* software updated developed by *Boeing* have not been acceptable to the *U.S. FAA*. In fact, the most recent *M.C.A.S.* software update by *Boeing* has revealed and illuminated an additional new flaw, the *M.C.A.S.* microprocessor. “In simulator tests, government pilots discovered that a microprocessor failure could push the nose of the plane toward the ground,” according to Prokupecz, Griffin, and Wallace (2019). “It is not known whether the microprocessor played a role in either crash” (Prokupecz et al., 2019).

The *Boeing M.C.A.S.* Band Aid© fix of the *Boeing 737 MAX* wing design flaw has been a failure and continues to have accumulating problems known and unknown. Still, to the day of this writing, July
29, 2019 Boeing refuses to acknowledge the Boeing 737 MAX wing design flaw, or any design flaw and/or fault by The Boeing Company. The wing design flaw of the Boeing 737 MAX is like an extremely deadly tumor similar to ovarian cancer and/or pancreatic cancer. It will stay there and continue to cause problems and metastasize, or spread, until the primary source tumor is surgically resected, or removed, from the design. The case is the same for the Boeing 737 MAX. Further continuation of a decisively and unquestionably proven fix is not possible with only a software and/or microchip processor fix of the M.C.A.S. system by Boeing. Moreover, further continuation of Boeing efforts to update and patch up the M.C.A.S. for the U.S. F.A.A. regulators and stockholders will be ultimately futile in my opinion. However, American Airlines has publicly stated “American Airlines remains confident that impending software updates to the Boeing 737 MAX, along with the new training elements Boeing is developing in coordination with our union partners, will lead to recertification of the aircraft this year,” according to American Airlines (2019).

All Boeing and Boeing 737 MAX stakeholders including: passengers, flight crew, mechanics, regulators (e.g. F.A.A., etc.), and the U.S. Congress must have absolute and unwavering confidence that the Boeing 737 MAX is unquestionably safe to return to the air in the unforgiving environment and arena of global airline operations. The flawed Boeing 737 MAX wing must be rooted out of the problem and all equations and strategies.

One notable and valid argument and problem for this recommendation is the amount of time, resources, and finance required to fix the Boeing 737 MAX wing problem. The current ongoing strategy of The Boeing Company is to re-design the software system for Boeing 737 MAX M.C.A.S. This takes a significant amount of time to research develop, code, and test the software. The software upgrade is a non-material item. The software does not require materials and/or chain-supply, thus it is not a materialized physical item. The upgrade is software. Therefore, the majority of all variables are in Boeing’s hands and can be accelerated and/or decelerated based on commands. Boeing is not dependent on the actual material and/or supplies. Boeing can get and commit to a strategic alliance with expert
software makers like its neighbor Microsoft, and/or Oracle that are experts in software design and testing to supplement and augment the software upgrade/re-engineer process. Moreover, Microsoft and/or Oracle could help troubleshoot and fix software problems during the alpha and beta testing phases, prior to critical U.S. F.A.A. re-evaluation of the Boeing 737 MAX M.C.A.S.

The Boeing 737 M.C.A.S software update provides the potential for maximal value and Return On Investment (R.O.I.) to get the Boeing 737 MAX reinstated and recertified by the U.S. F.A.A. for commercial operations, globally. The Boeing C.E.O./President/Chairman Dennis A. Muilenburg, Boeing Board of Directors (B.O.D.’s), stockholders, airlines, passengers, pilots and stakeholders may not have the patients, commitment, desire, motivation, and/or brand and company loyalty to fully commit to the wing redesign and fix. The number one way to decrease brand loyalty is to let the customers down, according to Forbes Agency Council (2018). The global grounding of the Boeing 737 MAX most certainly reaches the absolute top tier of customer disappointment. Boeing and their stakeholders most certainly want to alleviate this disappointment as soon as possible. The software upgrade for the Boeing 737 M.C.A.S. may just be the correct solution. However, the unknowns of the M.C.A.S. fix for the flawed Boeing 737 MAX wing provide great peril for all stakeholders. Therefore, I give me highest recommendation of re-designing and re-engineering the wing of the Boeing 737 MAX, moving forward. If The Boeing Company commits a $1.8 Billion U.S.D. to the new wing development and the program is terminated with all associated finance lost, it would only account for fifty percent (50%) of the first quarter financial loss of the Boeing 737 MAX grounding.
Implementation Plan of Action for the Boeing 737 MAX Wing Re-Design/Re-Engineer

In order to effectively and move positively forward, the implementation plan for the Boeing 737 MAX wing re-design and re-engineer must be well thought out, calculated, planned and executed. All current Boeing 737 MAX owners and orders must be given complete assurance that their aircraft will be absolutely fixed and the aircraft will not fly and/or operate until it is deemed unquestionably safe.

Moreover, all current owners must be full compensated financially for the grounding of the Boeing 737 MAX. The Boeing Company should charge its accounting department with having a loss of operations cost for each Boeing 737 MAX delivered that is fair and reasonable on a customer specific manner. It is essential that Boeing restore faith and integrity in an unwavering manner in both The Boeing Company and the Boeing 737 MAX brand to move forward both positively and effectively.

First, all archived data on the initial design and previous modifications of the Boeing 737 MAX wing must be retrieved, compiled and presented to the wing redesign/reengineering team with no redactions and incomplete and crystal-clear transparency. A critical assessment and recommendation list must be completed within sixty (60) days as the first major milestone for the new project.

Next, the new wing for the Boeing 737 MAX should be designed from an initial template of the previously and successful version of the Boeing 737, the Boeing 737 Next Generation (N.G.). The fundamental framework wing design structure of the Boeing 737 N.G. should be modified to provide outstanding structural support for the new and powerful CFM Leap-2B turbojet engines. Each modification of the new wing design should be routinely tested in the wind tunnel to detect any similar instability characteristics previously noted in the 2012 design, at the earliest possible time. Incremental and positive stepwise development of the new wing will provide rapid design operations progress reports and “Stop-Gates” for problems as they occur and accumulate. A six month to a nine-month time frame
should be accounted for the new “clean sheet” wing design of the Boeing 737 MAX. The accounted for
time frame for the Boeing 737 MAX wing analysis and redesign/re-engineering should be no longer than
twelve (12) months, or one year.

When the new Boeing 737 MAX wing design has reached its maximal design efficiencies with no
instabilities, the Boeing test pilot team should be brought into critically evaluate the wind tunnel test data
with the engineers. Simultaneously, the first prototype wing should be made to actual flight testing. The
Boeing test pilot team can provide further evaluation, testing, and insight into any potential and/or
conceivable problems with the wing, while the full-scale prototype wing is being constructed. The full-
scale prototype wing should be constructed in no longer than a three-month time frame, with an additional
month for final assembly of the aircraft.

If no problems are detected, Boeing should plan on producing four identical and fully equipped
Boeing 737 MAX aircraft with the newly redesigned/re-engineered wing. In order to have absolute
confidence in the aircraft, The Boeing Company should have the newly winged Boeing 737 MAX
completely recertified from scratch, or anew. Four fully operational Boeing 737 MAX test aircraft will
provide sufficient resources to fully recertify the aircraft. Moreover, the Boeing test pilot team should be
given full resources, full support, and full assurances to test the aircraft utilizing their “Death Board”
strategy. The “Death Board” strategy provides unrestricted free reign for the Boeing test pilot team to test
any and every conceivable and/or possible or potential flaw in the aircraft, according to Gates and Baker
(2019).

Once the newly winged Boeing 737 MAX is certified by the U.S. F.A.A., all previously delivered
and produced Boeing 737 MAX’s should be have the new wing installed and rigorously flight tested prior
to returning to the customer. The 4,415 remaining Boeing 737 Max’s ordered should provide ample
motivation and incentivization for the Boeing 737 MAX stakeholders to truly fix the genesis of the Boeing
737 MAX problem, the flawed wing design. The previously four-hundred delivered and produced Boeing
737 MAX account for approximately ten percent (10%) of the outstanding orders. Boeing should replace
these aircraft wings with the newly designed wing, which will require both U.S. F.A.A. certification and approval.

**Figure 2: Boeing 737 MAX New Wing Implementation Timeline.**

It is possible, however vary unlikely, that a new safe wing for the Boeing 737 MAX can not materialize due to unforeseen variables and/or circumstances. The initial critical evaluation of the existing Boeing 737 MAX wing that is flawed and a painstakingly designed and planned development and reengineering phase (12 Months; 1 Year) should minimize that potential to the absolute lowest possible. If “Game Changers” and/or “Show Stoppers” are detected early in the first six (6) months of the re-design/re-engineering phase time (12 Months; 1 Year), then any loss of investment and resources will be minimized if the plan needs to be suspended, discontinued, and/or terminated.

Another issue that needs to be directly, diligently, and aggressively addressed is throughout implementation of the new wing is crystal clear public transparency to all stakeholders and the public.
1) The newest upgraded and updated Boeing 737 MAX has been globally grounded since March 13, 2019, following two fatal crashes with no survivors and three-hundred and forty-six (346) fatalities.

2) The definitive causes of both crashes have yet to be determined.

3) The Boeing Company failed to disclose the existence of the new M.C.A.S. to Airlines and Pilots.

4) Based on credible and valid data from several sources, the global consensus for the probable, or “Root,” cause of both crashes is the new Boeing Maneuvering Characteristics Augmentation System (M.C.A.S.).

5) The Boeing M.C.A.S. was developed, implemented, and deployed to fix a native flaw in the design of the new Boeing 737 MAX wing.

6) The Boeing Company is re-designing the M.C.A.S. software and plans to submit the software update and associated airworthiness certification package to the U.S. F.A.A. for review by the end of September 2019.

7) The Boeing Company is hopeful that the Boeing 737 MAX will be approved and cleared for commercial operations by the U.S. F.A.A. toward the end of October 2019.
8) Updating and fixing the Boeing 737 MAX M.C.A.S. software will not fix the flawed wing design.

9) The Boeing Company stock price has dropped 18% since the global grounding of the Boeing 737 MAX.

10) The Boeing Company earning statement for the first quarter of the Boeing 737 MAX grounding (Q2-2019) took a $5.6 Billion United States Dollar (U.S.D.) accounting charge attributed to the grounding.

11) The grounding of the Boeing 737 MAX gave The Boeing Company a quarterly (Q2-2019) financial loss of $3.6 Billion U.S.D., the largest loss ever in The Boeing Company history.

12) The Boeing Company lost a $6 Billion U.S.D. order for Boeing 737 MAXs’ grounding from Saudi Arabia’s Flyadeal airlines. Flyadeal airlines then placed an equivalent $6 Billion U.S.D. order with Airbus for the Boeing 737 MAX equivalent, the Airbus A320neo aircraft.

13) Herein, this report highly recommends re-designing and re-engineering the flawed Boeing 737 MAX. Thereby, eliminating the need for the faulty M.C.A.S.

14) Herein, this report proposes an implementation plan that has a new Boeing 737 MAX prototype flying in rigorous flight and simulator testing in no longer than eighteen (18) months, or one and a half years. The enclosed proposal recommends and projects that all existing produced Boeing 737 MAX’s are retrofitted with the new wing in no longer than four (4) years.

Fixing the flaws Boeing 737 MAX wing with a newly redesigned one should provide an unquestionably safe return to global operations, while also providing the sustained “Cash Cow” for The Boeing Company for the foreseeable future. Moreover, fixing this flaw in a definitive and generous manner will restore the Preeminent reputation and safety to The Boeing Company, the Boeing 737 MAX brand, and the U.S. F.A.A.
The Boeing 737 MAX Case Study Relevance to the General Business Field and Market

The critical Boeing 737 MAX case study analysis herein, provided an opportunity for rigorous literature (e.g. press reports, investigation reporting, government regulatory compliance, government responses, etc.) research and review, critical thinking, analytical evaluations on both technical and business levels, generation of credible, viable, and promising solutions. Additionally, a strong and valid argument for the recommendation for Boeing to re-design/re-engineer the wing of the Boeing 737 MAX submitted is balanced with critical arguments against, including possible problems and/or failures of the recommendation and associated implementation plan.

A significant challenge in this case study analysis was the complex Boeing 737 MAX problem is a current, ongoing and fluid real-time technical, business, regulatory, and political problem on a global scale. Therefore, this case study is not a singular finite concluded episode/event and/or a forensic case study analysis based on a single case study paper. The learning and analysis of all the aspects of business (e.g. Accounting, Finance, Ethics, Legal, Regulatory, Program Management, Operations Management, Global Business Operations, Organizational Theory, etc.) were dynamically interweaved in many different lenses and frames providing a coalescent business case study analysis, herein. This case study analysis experience, findings, and deliverables can be applied to many different aspects of business in general. Moreover, consistent critical analysis, thinking, and problem solving of this complex Boeing 737 MAX case study in the context of applied full-spectrum business is a very challenging problem The Boeing Company is currently trying to manage and find a successful solution for all of its stakeholders.
Closing Arguments and Concluding Remarks

The Boeing Company reputation and safety reputation, reliability, and trustworthiness has plummeted since the global grounding and investigations of the Boeing 737 MAX program started. The Boeing C.E.O./President/Chairman Dennis A. Muilenburg stated “Safety is our problem, we own it,” according to Boeing-m (2019). Captain Chesley “Sully” Sullenberger III, the legendary captain whom managed the Miracle on the Hudson (U.S. Airways Flight #1549), stated in reference to the Boeing 737 MAX situation and handling of the situation “We shouldn’t be blaming dead pilots and we shouldn’t expect pilots to compensate for flawed designs,” according to Irving (2019).

The Boeing Company needs to “Own” its behavior, conduct, decisions, services, and products. Reputations are nearly everything, and are very difficult to build to reach the highest level. While reputations are a Great challenge to cultivate, develop, and maintain, they can easily be permanently scared, destroyed, and shattered. Such is the case with The Boeing Company and the U.S. F.A.A. handling of the Boeing 737 MAX problem and safety record.

The Boeing Company appears and seems to be poised and determined to finally get a fix for the flawed Boeing 737 MAX wing with a software update to the M.C.A.S. I strongly feel and fear that the M.C.A.S. fix may not fix the flawed wing and future fatalities will accumulate if the Boeing 737 MAX flies again without fixing the flawed wing.

I think and believe it is imperative that the flawed Boeing 737 MAX wing be fixed to make the aircraft safe to operate commercially. Moreover, fixing the wing should restore trust and confidence in the Boeing 737 MAX aircraft, The Boeing Company, and the U.S. F.A.A. to a credible, safe, and comfortable level.
References


Retrieved from:


Retrieved from:

[https://www.boeing.com/company/about-bca/](https://www.boeing.com/company/about-bca/)


Retrieved from:

http://www.boeing.com/commercial/737max/first-flight/


Retrieved from:

https://www.boeing.com/commercial/737max/


Retrieved from:

http://www.boeing.com/company/


Retrieved from:

http://www.boeing.com/company/bios/dennis-a-muilenburg.page


Retrieved from:

[https://www.boeing.com/commercial/737max/737-max-software-updates.page](https://www.boeing.com/commercial/737max/737-max-software-updates.page)


Retrieved from:

[https://www.boeing.com/commercial/](https://www.boeing.com/commercial/)


Retrieved from:


Retrieved from:

[https://www.boeing.com/company/general-info/](https://www.boeing.com/company/general-info/)


Retrieved from:


Bogaisky, J. (2019, April 5). *Boeing Cutting 737 Production Amid Crash Investigations And Delivery Freeze*. Forbes.


Retrieved from:


Retrieved from:

https://www.britannica.com/topic/Boeing-Company


Retrieved from:

https://www.cfmaeroengines.com/


Retrieved from:

https://www.faa.gov/aircraft/air_cert/airworthiness_certification/


Retrieved from:


Retrieved from:

https://www.faa.gov/news/updates/?newsId=93206


Retrieved from:


Retrieved from:


Retrieved from:


Retrieved from:


Retrieved from:


Retrieved from:

Hill, C. (2019, March 1). *Doing This Could Get You Free Flights On JetBlue For An Entire Year – But It Won’t Be Easy.* www.marketwatch.com

Accessed on August 1, 2019.

Retrieved from:


Retrieved from:

https://www.seattletimes.com/business/boeing-aerospace/spirit-aerosystems-withdraws-forecast-on-reduced-737-max-output/
Josephs-a, L. (2019, June 19). Boeing Wins First 737 Max Order Since Deadly Crashes In A 200-

*Plane Vote Of Confidence.* [www.Msnbc.com](https://www.msnbc.com)


Retrieved from:


Josephs-b, L. (2019, July 22). Boeing Slides After Rating Agencies Turn Negative On Marker Of

*Grounded 737 Max.* [www.Cnbc.com](https://www.cnbc.com)


Retrieved from:


Kriel, R. and John, T. (2019, March 10). No Survivors In Ethiopian Airlines Boeing 737 Crash


Retrieved from:


Retrieved from:


Retrieved from:


Retrieved from:


Retrieved from:


Retrieved from:


Retrieved from:

https://www.merriam-webster.com/dictionary/stakeholder


Retrieved from:


Retrieved from:

https://www.npr.org/2019/02/14/694620105/airbus-to-stop-production-of-a380-superjumbo-jet


Retrieved from:


Travis, G. (2019, April 18). *How The Boeing 737 Max Disaster Looks To A Software Developer.*

Retrieved from:


UPS. (2018, February 1). *UPS Commits To Purchase 14 New Boeing 747-8 Freighters And Orders 4 New 767’s.* www.pressroom.ups.com


Retrieved from:

https://pressroom.ups.com/pressroom/ContentDetailsViewer.page?ConceptType=PressReleases&id=1517490783017-178


Retrieved from:

https://www.reuters.com/article/us-usa-boeing-af1/boeing-gets-3-9-billion-contract-for-new-air-force-one-jets-idUSKBN1K72SH
Zhang, B. (2019, April 15). Boeing Can’t Deliver The 737 MAX To Customers, And Now The


Retrieved from: