RESEARCH REPORT

VTT-R-00804-21

Regulatory lessons from accidents due to institutional failures: Boeing 737 MAX and Deepwater Horizon

Authors: Nadezhda Gotcheva and Marja Ylönen

Confidentiality: VTT Public

Version: 24.9.2021

VTT

beyond the obvious

Report's title	
Regulatory lessons from accidents due to institutional failures: Boeing 737 MAX and Deepwater Horizon	
Customer, contact person, address Pia Oedewald STUK PL 14, FI-00881 Helsinki	**Order reference**
Project name Regulatory lessons from accidents due to institutional failures: Boeing 737 MAX and Deepwater Horizon	**Project number/Short name** 129484-1.2 /DeepMaxLearn
Author(s) Nadezhda Gotcheva and Marja Ylönen	**Pages** 19
Keywords accident, institutions, safety, regulator	**Report identification code** VTT-R-00804-21

Summary

Regulatory lessons from accidents due to institutional failures: Boeing 737 MAX and Deepwater Horizon (DeepMaxLearn) project was commissioned by the Management Board of SAFIR2022 programme as a part of the SAFIR2022 administration project. Causes of accidents often have institutional origins and recent research highlighted the importance of better understanding the institutional perspective on disaster development (Verweijen and Lauche, 2019).

The objective of the DeepMaxLearn project was to analyse the institutional factors related to the Boeing 737 MAX and Deepwater Horizon accidents to provide STUK and the nuclear industry with relevant lessons and insights for the regulatory safety oversight and overall operations. The study focuses on institutional factors in the regulatory context, in the interaction between the authority and the operator and the weak signals that could have been detected in the operator's context and activities, including operator's business and operational environment.

The study methods and data included a background interview with a retired pilot and aviation journalist, analytical desktop work, covering accident investigation reports; selected investigative and other media publications; annual reports of Boeing (2012-2018) and scientific articles, as well as a virtual workshop to present and discuss the results with the Radiation and Nuclear Safety Authority in Finland (STUK), representatives of the nuclear power companies in Finland and the Swedish Radiation Safety Authority SSM. Analysis was done by focusing on institutional factors – those relatively stable social structures, which shape the political, economic and social interactions over time to create order, reduce uncertainty and ensure legitimacy of organizations.

Results are presented regarding both cases of Boeing 737 MAX and Deepwater Horizon, followed by summary of the lessons learned and implications for the regulator and nuclear industry companies. Factors are elaborated with regards the role of national government and political influences, the importance of independence of the regulator, resources and competences of the regulator, critical changes in decision-making power of engineers, safety vs. profit tension and related drivers, organizational mergers and outsourcing as critical changes, role of educational institutions for framing the way of thinking and solving problems, the interlinkages between product safety, process/operational safety, and worker safety.

Confidentiality	VTT Public

Tampere, 28.10.2021

Written by	**Reviewed by**
Nadezhda Gotcheva, Research Team Leader	Merja Airola, Senior Scientist

VTT's contact address
VTT Tampere, Visiokatu 4, FI-33101

Distribution (customer and VTT)
SAFIR2022 SG1, RG1 and VTT

Approval

VTT TECHNICAL RESEARCH CENTRE OF FINLAND LTD

Date:	31.10.2021
Signature:	DocuSigned by: 7263857D1F2B476...
Name:	Petteri Alahuhta
Title:	Vice President, Cognitive Production Industry

Contents

1. Introduction

DeepMaxLearn project was commissioned by the Management Board of SAFIR2022 programme as a part of the SAFIR2022 administration project.

Analysing high-profile accidents in safety-critical domains can provide valuable lessons for various stakeholders in other safety-critical domains. Analysing such accidents from a new perspective has the potential for uncovering nuances and weaving a cohesive tale of lessons learned and recommendations to be taken into consideration by the regulator. In this small project, the new perspective is **institutional factors** - the 'rules of the game' that explicitly or implicitly govern organizational and individual behaviours (North, 1990). Causes of accidents often have institutional origins and recent research highlighted the importance of better understanding the role of institutions for disaster development (Verweijen and Lauche, 2019).

This study focuses on analysing specific accidents in aviation and oil & gas industry: the Boeing 737 MAX airplane crashes and the Deepwater Horizon accident. These accidents have been analysed thoroughly and described voluminously in various investigation reports, e.g. The House Committee on Transportation and Infrastructure (2020) and the National Commission (2011) reports, therefore they are not described in detail here (Fig. 1).

OIL & GAS

- On April 20, 2010 in the Gulf of Mexico on the British Petroleum (BP)-operated Macondo Prospect, the Deepwater Horizon drilling rig exploded: 11 people died and 17 were seriously injured. The environmental devastation is considered the largest marine oil spill in the history of the petroleum industry.

AVIATION

- On 29 October 2018, Lion Air flight 610, a Boeing 737 MAX 8, took off from Jakarta for a domestic flight to Pangkal Pinang, on the Indonesian island of Banka: 30 minutes after takeoff, the plane crashed into the Java Sea, killing all 189 passengers and crew.
- On 10 March 2019 Ethiopian Airlines flight 302, a Boeing 737 MAX 8, bound for Nairobi, Kenya crashed only 6 minutes after takeoff, from Addis Ababa, Ethiopia, killing all 157 people on board.

Figure 1. The Deepwater Horizon and Boeing 737 MAX 8 accidents.

The accidents have occurred in tightly regulated industries and in long-established, highly-respected global companies in the aviation and petroleum industry. Against the background of technical phenomena, the abundance of investigation reports revealed a wealth of issues related to the companies' operational environment and culture, regulatory context, supply networks, as well as human and organizational factors, all of which have had an impact on the development of accident conditions.

For STUK, it is timely and important to further develop its risk-informed oversight while renewing the safety requirements to emphasize the responsibility for safety to the licensee. Therefore, it is essential to identify possible lessons these accidents could bring to STUK as a regulator, as well as to the nuclear industry organizations. Many other organizations globally, such as the Canadian Nuclear Safety Commission (2020) and NASA (2011) have also been analysing what can be learned from these accidents, occurring in a different safety-critical industry and context.

2. Objective

The objective of the DeepMaxLearn project was to analyze the institutional factors related to the Boeing 737 MAX and Deepwater Horizon accidents to provide STUK and the nuclear industry with relevant lessons and insights for the regulatory safety oversight and overall operations.

The study tackles three research questions, as follows:

1. What institutional factors in the **regulatory context**, including operations and resourcing, can be considered as influencing the course of development in the short and/or longer term?

2. What factors in the **interaction between the authority and the operator** can be considered as influencing the course of development in the short and / or longer term? Both inter-organizational and intra-organizational relationships will be considered.

3. What **weak signals** could have been detected in the operator's context and activities, including operator's business and operational environment that the authority should have noted and addressed at a sufficiently early stage? "Weak signals" are the first indicators of changes that may become significant in the future (Dufva, 2019).

This study considers both the operational context of the regulators and operator companies, and the interactions between them. In this report the words "operator" and "operator's context" are used to denote the key organizations involved and how they have been operating at the times preceding the accidents. For example, we focus on Boeing as a design, manufacturing and service provider aerospace company, not on the airlines operating the aircrafts; airlines are Boeing's customers. Given the abundance of material in this regard, the focus is on institutional context and pressures deriving from it, such as, for example the role of government, legal framework, political factors, economic drivers, increasing competition or conflicting demands, and related decision-making.

3. Method and data

Study methods and data included the following:

1) Background interview with a retired pilot and aviation journalist;

2) Analytical desktop work:
   - Publicly available accident investigation reports;
   - Investigative and other media publications;
   - Public records: Annual reports of Boeing (2012–2018)
   - Scientific articles

3) Virtual workshop to present and discuss the results with the Radiation and Nuclear Safety Authority in Finland (STUK), representatives of the nuclear power companies in Finland and the Swedish Radiation Safety Authority was held on 25th of August 2021.

The material was analyzed to identify those relatively stable social structures, which seemed to shape the political, economic and social interactions over time to create order, reduce uncertainty and ensure legitimacy of the organizations.

4. Institutional factors

Institutions are “humanly devised constraints that structure political, economic and social interactions” to create order and reduce uncertainty in society (North, 1990). The constraints can be both formal (rules, laws, regulations and other enforcement mechanisms) and informal (norms of behaviour, codes of conduct, sanctions). In essence, institutions are relatively stable social structures (Scott, 1995), such as governance structures, or the belief systems and related practices that set up whole industries and their regulatory mechanisms.

Institutional theory focuses on the processes, by which these structures become established as authoritative guidelines for social and organizational behaviour, and it has been associated with path dependence, inertia, and seeking legitimacy in the organizational field (e.g. in a specific industry) to ensure continuity and success (Scott, 2001; Greenwood et al., 2012). Legitimacy is the “the degree of cultural support” (Meyer and Scott, 1983) by which companies can gain and enhance support and recognition from their key institutional stakeholders. Gradually, taken-for-granted beliefs and practices become deeply rooted, stable, institutionalized (i.e. hard to change) in organizations and whole industries. Although operational conditions are changing, the deeply rooted assumptions are not so quick to change, and this may be risky.

Institutional logics are social constructs, a macro-level phenomenon that shape the cognition and behaviour of organizations and individuals based on historical patterns (Friedland and Alford, 1991; Dunn and Jones, 2010). They provide means to make judgments about an actor’s legitimacy of existence and performance. Examples of institutional logics are maximizing profits in finance organizations, care logic in nursing and medical education, or benevolent logic of non-governmental organizations (NGOs). In practice, multiple institutional logics co-exist and organizing occurs in institutionally pluralistic setting (Greenwood et al., 2011), but when demands of multiple logics are highly divergent or even conflicting, an organization faces institutional complexity, which needs to be resolved to avoid organizational paralysis (Pache and Santos, 2013).

5. Results

The main findings of the study are presented, following the logic of the research questions. In both cases - Deepwater Horizon and Boeing 737 MAX 8 accidents – quite similar institutional factors were identified as contributing to slipping into accident conditions, and yet each accident case had its own specifics.

As a background, both BP and Boeing are major, well-established global companies, which have been praised multiple times for outstanding performance. For example, prior to the accidents, as of April 2010, BP had not had a single “lost-time incident” in seven years of drilling (NASA, 2011). Boeing has been an iconic company for decades, it celebrated 100 years two years before the first 737 MAX crash. On 22 October 2018, the National Safety Council (NSC) presented the Boeing company with 2018 Robert W. Campbell Award, stating that the “aviation leader finds innovative ways to address common workplace safety issues and protect employees.” (NRC, 2018).

Both BP’s Deepwater Horizon and Boeing 737 MAX operational ecosystems have been very complex, comprising a number of key organizations and contractors, often respected companies, world leaders in their field, and a long and complex supply chain (especially in the Boeing’s case; see Figures 2 and 3). In these figures the higher level factors and key organizations are not depicted but they played a key role in shaping the conditions, in which these companies and whole ecosystems were allowed to operate. Institutional actors are actually shaping the “rule of the game” over decades. Here we refer to powerful yet largely intangible mechanisms unfolding over time, by which key actors set the institutional environment, e.g. government arrangements, national energy policy and other policies, legal framework, industry lobbying and public relations.

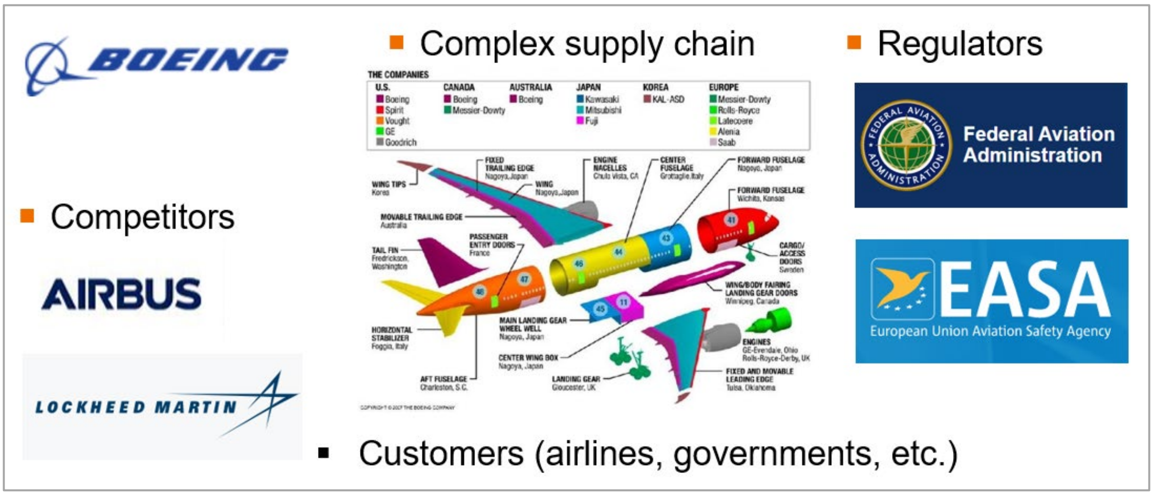

Figure 2. A simplified view on Boeing MAX ecosystem (key organizations and other actors) (Source: The Boeing company and Wikipedia).

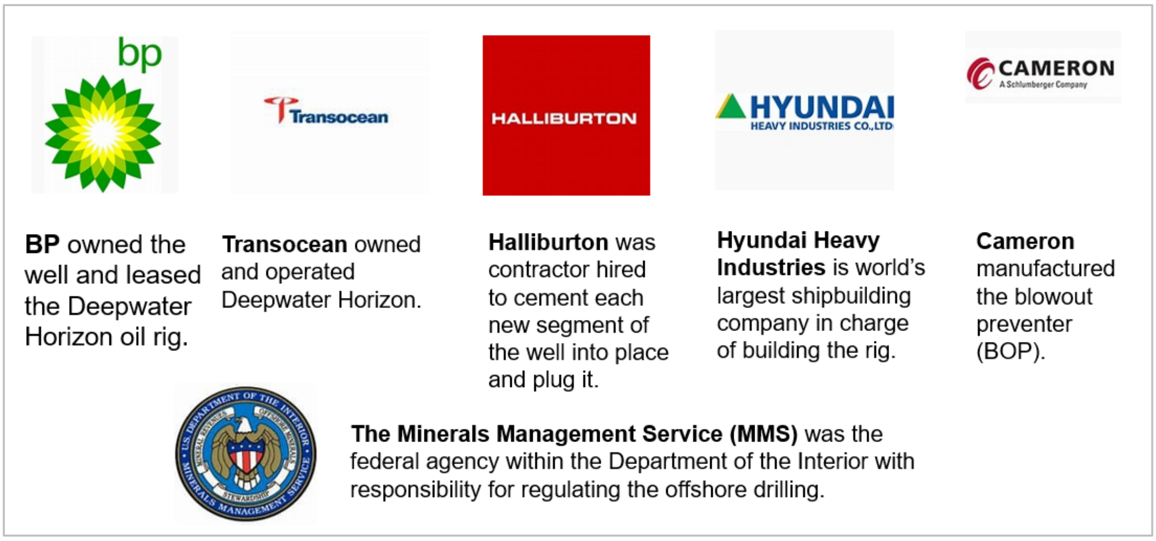

Figure 3. Key organizations in the BP's Deepwater Horizon ecosystem: a simplified view.

5.1 Regulatory context

5.1.1 Boeing 737 MAX: Federal Aviation Administration oversight

The Federal Aviation Administration (FAA) is the agency of the United States Department of Transportation responsible for the regulation and oversight of civil aviation within the U.S., as well as operation and development of the National Airspace System. Its primary mission is to ensure safety of civil aviation. Officially established in 1967, the foundations of FAA have been originally created in the 1950s, and dated even much earlier in the 1920s, when the Air Commerce Act was passed in 1926. In 2020, the FAA celebrated 100 years of history (Simple Flying, 2020).

Insights from the background interview indicated that the role of FAA was not to regulate the company's activities and processes but to oversee and certify the product (e.g. the aircraft). Furthermore, certifying a brand new aircraft would have required considerable resources from FAA; instead, major part of the certification was handled by the manufacturers of this same plane instead of independent FAA inspectors.

The 737 Max was approved under the FAA's "Organizational Designation Authorization" (ODA) program, which was created by FAA in 2005 and finalized in 2009 "to standardize its oversight of aircraft manufacturers that have been approved to perform certain functions on the Agency's behalf, such as determining compliance with aircraft certification regulations." (Office of Inspector General, 2015). The ODA program effectively allows the aircraft manufacturers to certify parts of their own designs with limited federal oversight. According to Boeing data, as of March 2017, FAA delegated all 91 certification plans to Boeing's ODA.

With regards identifying stable structures from institutional perspective, we observed that the FAA has long delegated safety certification duties to companies and individuals, as resource limitations have meant that agency employees were not able to personally monitor every aspect of certification processes. The historical and legal reasoning behind were specified as follows:

"The U.S. civil aviation industry is vital to the Nation's economy and encompasses more than 200,000 aircraft, 1,600 approved manufacturers, and 5,400 aircraft operators, among others. Recognizing that it is not possible for Federal Aviation Administration (FAA) employees to oversee every facet of such a large industry, public law [49 U.S.C § 44702] allows FAA to delegate certain functions, such as approving new aircraft designs and certifying aircraft components, to private individuals or organizations. Designees perform a substantial amount of critical work on FAA's behalf. For example, one aircraft manufacturer approved about 90 percent of the design decisions for all of its own aircraft." (Office of Inspector General, 2015)

According to the US Federal Register (2005), since the "beginning in the 1940s, the FAA's predecessor agency, the Civil Aeronautics Administration (CAA) established programs to appoint designees to perform certain tasks for airman approvals, airworthiness approvals and certification approvals." In the 1950s, the rapid expansion of the aircraft industry triggered the development of various forms of organizational delegation by FAA to meet specific needs. Figure 4. illustrates the development and evolution of organizational delegation since the inception of the program in the 1950s.

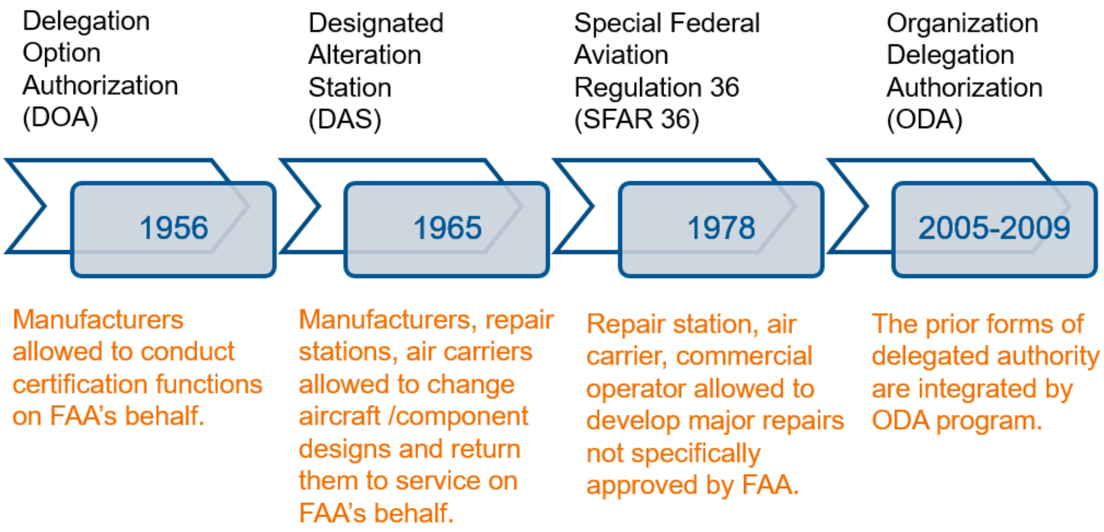

Figure 4. History of delegated authority in FAA (Source: Office of Inspector General analysis of FAA documents, Report Number: AV-2016-001, 2015).

From an institutional perspective, this illustrates that the FAA has a long history of delegating oversight without closer verification or follow-up. The institutionalization of this practice was allowed legally by US public law and fuelled economically by the rapid growth of aviation industry and limited FAA resources. Key benefits of ODA were to improve the efficiency and lower the cost of certification processes (Office of Inspector General, 2015). However, the ODA program has faced repeated criticism from the

Transportation Department's Inspector General. In 2015 there was a warning that under the program the agency was not prioritizing oversight of "the highest-risk areas," like new aircraft designs, and that it did not have an adequate system for determining whether the teams overseeing certifications were sufficiently staffed. The lack of independent design verification by experts also contributed to the "crash of the regulatory system" (Sgobba, 2019).

Furthermore, a number of ODA program controversies were identified (U.S. Department of Transportation, Office of Inspector General, 2020, Report No. AV2020037; 2021, Audit Report AV2021020), for instance:

- U.S. Department of Transportation, Office of Inspector General has reported since 2011 that "FAA faces challenges in overseeing ODA companies, including Boeing. For example, in October 2015, during the timeframe of the Boeing 737 MAX 8 certification, they reported that FAA's oversight of ODA program controls was not systems- and risk-based as recommended by an aviation rulemaking committee. Instead, FAA's oversight was more focused on individual engineering products and areas that we determined were low risk."
- FAA lacked a comprehensive process for determining staffing levels needed to provide ODA oversight;
- Conflicting roles and lack of independence: Boeing ODA has nearly 1,500 personnel; however, ODA administrators and unit members perform those duties only part-time. The same engineer can work for the company on a particular design and then approve that same design as an ODA unit member. Boeing ODA managers who administer the program also have concurrent roles within Boeing.

As a potential institutional barrier we refer to the role of the European Union Aviation Safety Agency (EASA): the 737 MAX gained FAA certification on March 8, 2017, and it was approved by EASA only 13 working days later, on March 27, 2017. We cannot take a stance on this fact as we are not aware of the nature of the internal inter-agency approval processes.

5.1.2 Deepwater Horizon: Minerals Management Service oversight

The Minerals Management Service (MMS) was created in 1982 as an agency of the United States Department of the Interior that managed the nation's natural gas, oil and other mineral resources on the outer continental shelf (OCS).

As indicated by Davis (2012), "the roots of the Deepwater Horizon blowout and spill run deep and grew from seeds planted well before the Macondo well was drilled. Oil and gas development has often been shrouded in overlapping veils of national energy policy, environmental policy, local economic and cultural priorities, environmental advocacy, and industry lobbying and public relations". From institutional perspective, Davis's insight also pointed to the role of the American Petroleum Institute (API) as an example of an organization "which has played a dominant role developing safety standards for the oil and gas industry, yet which lobbies for the industry and favours rulemaking that promotes industry autonomy from government oversight." The American Petroleum Institute (API) is the only national trade association that represents all aspects of America's oil and natural gas industry – it has more than 600 corporate members (ref. API website).

From institutional perspective, evidence from the Deepwater Horizon investigation reports indicated that the MMS inspectors were underpaid, compared with similar jobs in the industry – this may have affected their motivation and slippery relations with the industry, as shown in the later chapters. Importantly, it was allowed that MMS as a regulator has been understaffed – they did not have enough resources to perform their oversight duties with high quality. For example, the Safety Oversight Board found that the Gulf of Mexico Region "employs 55 inspectors to inspect about 3,000 facilities, which is a ratio of 1 inspector for every 54 facilities."

This lack of resources also affected another characteristic of the regulatory context. MMS had a pattern of lagging behind with developing and updating safety regulations, and there has not been an institutional mechanism to monitor and shift this pattern. For instance, MMS indicated willingness to adopt a more rigorous and effective risk-based safety regulatory regime some 20 years before Deepwater Horizon accident but the regulations have been repeatedly refined, delayed, or eventually abandoned.

In fact, MMS regulations have been reliant on industry to document and accurately report on operations. MMS own competence and power to impose actions to the industry have been limited. They have been relying on outdated guidance and instructions developed between 1984 and 1991. The inspectors did not have adequate guidance on how to do oversight: they have been operating “relatively independently, with little direction as to what must be inspected or how,” equipped with a handbook of "potential incidents of noncompliance”. NASA (2011) reported that “when industry contended that blowout-preventer stacks – the critical last line of defense in maintaining control over a well – were more reliable than the regulations recognized, warranting less frequent pressure testing, MMS conceded and halved the mandated frequency of tests.” However, a series of third-party technical studies raised the possibility of high failure rates for the blowout preventers’ (BOP) control systems. More specifically, three engineering studies (2004, 2006, and 2009) commissioned by MMS – or done with MMS participation – identified many instances of BOP failures, e.g. 2009 study by West Engineering Services identified 62 instances of BOP failures. It was evident that as a regulator MMS was weak and timid: they had information that blowout preventers have 'safety critical' vulnerabilities yet the flaws did not result in federal safety alerts or tougher standards for BOP manufacturers.

Another lagging effect was that MMS was reportedly unable to keep up the adequacy of the regulation (e.g. drilling-safety requirements) with industry’s rapidly evolving deepwater technology. There have been no regulations governing the requirements for critical events, such as cementing a well, testing the cement used, or governing negative-pressure testing of the well’s integrity. Moreover, US Government has been interfering with the need to update the requirements and thus protecting the interests of the industry. Even when MMS proposed safety-critical regulatory initiatives, they have faced strong and effective opposition from most powerful institutional actors. According to NASA (2011), in 2003, the White House, under the Presidency of George W. Bush, opposed MMS’s efforts to update its requirements for the reporting of key risk indicators.

5.2 Interactions between the authority and the operator

The interactions between the authority and the operator could be described by a metaphor, which came from the background interview: the “fortress mentality” metaphor. This metaphor indicates that the interactions between both FAA and Boeing, and MMS and BP and associated oil and gas companies have been a way too close – they have all been inside the “fortress”, strengthened by a culture of exclusivity due to the uniqueness, and national and global importance of the aerospace and petroleum industries. The metaphor also relates to the concept of institutional isomorphism.

Figure 5. Illustration of the "fortress mentality" metaphor.

The analysis of relations indicated that Boeing had influence over the FAA's oversight structure. The mechanisms were so that FAA management overruled safety and design concerns of the FAA's own technical experts in order to protect the interests of Boeing.

Another layer of relations relevant from institutional perspective are the relations between the companies and the governmental, political structures, and the regulators. There have been complex, non-transparent relations between private and public in this sense. In the oil and gas industry, the so called Big Oil interests have been influencing and overriding US safety regulations and pressured towards cutting of safety testing while staying focused on profit-making[1]. As also indicated earlier, the regulator MMS had not sufficient resources nor power to intervene – they let the company decide for themselves. At MMS there have been evidences for corruption practices and broken code of conduct.[2]

Furthermore, there have been conflict of interest since MMS has double responsibilities when it comes to industries such as oil or natural gas: it must act as a regulator while also collecting royalties from the companies. The U.S. government technically owns resources such as the oil in the Gulf. Companies pay the federal government for the rights to drill in certain areas. "The MMS has a lot of incentive to collect as much, in the way of royalty income, as it can. That means pressure to authorize a lot of drilling and then to do everything possible [to make sure] that the flow of production is robust and unimpeded." (CNN, 2010).

According to Davis (2012), "between the years 2000 and 2010, the federal government collected between $4 billion and $18 billion per year in lease payments, royalties, and bonuses. It was the business of MMS to collect those sums, the same MMS that was supposed to regulate the oil and gas industry." The oil and gas development with little regulatory scrutiny became a generator of great profit to many in industry and a generator of vital revenues to federal, state, and local governments (Davis, 2012).

[1] Before BP oil spill, Big Oil-led study urged feds to cut safety testing - CSMonitor.com
[2] US rig inspectors received gifts from oil companies, report says - CSMonitor.com

5.3 Weak signals

In this chapter we address some of the main weak signals – signals of change – that could have been detected in the operator's context and activities, including business and operational environment that the authority should have noted and addressed at a sufficiently early stage.

Fierce competition between Airbus and Boeing affected decision-making, driven by economic institutional logic: ”the 737 MAX and the A320neo – ended up at the center of the biggest rivalry in the aviation world” (Wall Street Journal, 2019). The focus shifted towards production, outsourcing and cost cutting to ensure market positions of Boeing are not lost to Airbus. Airbus began winning orders from American Airlines, a longtime Boeing customer – “to win a chunk of the business, Boeing shelved its plan of creating an all-new 737 short-haul jet and followed in Airbus' footsteps by choosing the cheaper and quicker route of developing new engines.” (DW, 2011). This has led to “flaws and missteps in the design, development, and certification of the aircraft”. [3]

Production pressure and issues with open reporting: the DH investigation identifies production vs. safety pressures as underlying decision-making and operational behaviour in Deepwater Horizon. Many of the riskier operational decisions have been made due a desire to save time, costs, or ensure long-term viability of the well, and “without full appreciation of the associated risks” (National Oil Spill Commission 2011, p. 223). A survey of the Transocean crew prior to the incident found some employees to fear reprisals for reporting unsafe situations, and others felt staff shortages were limiting possibilities to do the work with high quality. In the Boeing case the engineers have been reporting safety concerns but these have been neglected.

Cultural shift: For more than 80 years, Boeing has been a very successful company with excellent engineering and scientific reputation. Boeing's corporate climate and culture started changing in the mid-1990s, when Boeing purchased McDonnell Douglas for $13 Billion. Boeing's senior engineers have been removed from the leadership team, which is an important weak signal. A successful engineering culture has been relatively quickly swept away by the dominating McDonnell Douglas executives' mindset, focused on increasing efficiency, cutting costs and maximizing profits for the shareholders (Levin 2019). Despite the fact that officially Boeing acquired McDonnell Douglas, the power dynamics resulted in the new Boeing President selected from McDonnell Douglas (Herkert et al., 2020) – this was another critical weak signal. Risks related to the merge of Boeing with McDonnell Douglas were not assessed and understood by FAA. Fig 6. shows some of the critical events in Boeing 737 MAX case in a timeline.

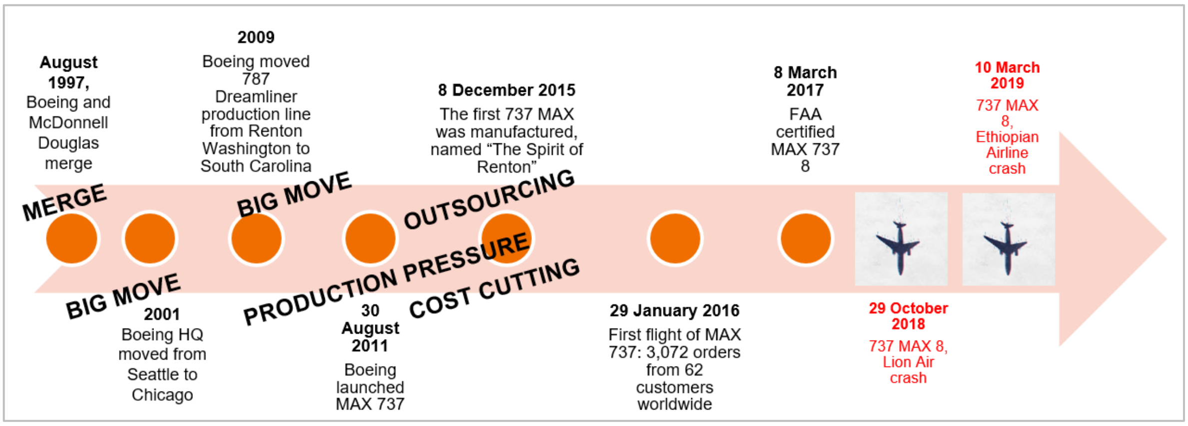

Figure 6. Boeing: A simplified timeline of some of the critical events.

[3] Airbus wins big with American Airlines | Business | Economy and finance news from a German perspective | DW | 21.07.2011, First 737MAX, 'Spirit of Renton,' makes first flight | Renton Reporter; House Transport Committee, Investigation report

In 1997, Boeing and McDonnell Douglas, the 1st and 3rd largest manufacturers of airplanes merged to form a single company[4]. Founded in 1967, McDonnell Douglas produced well-known commercial and military aircrafts. Following the merge, their combined annual sales were approximately USD 48 billion. Boeing's market share for large commercial jet aircrafts reached 70% (Economist, 1997). While the US Federal Trade Commission (FTC) approved the merger, the European Commission (EC) antitrust authority did not share the FTC confidence: the EU Competition Commissioner Karel Van Miert publicly objected to the merger. However, "United States lawmakers rejected the EU's authority and jurisdiction to block the merger, maintaining that the EU had no right to "tell American companies how to do business," and questioned its motive, believing the EU's protests were merely a means to protect and advance Airbus." (Karpel, 1998). "President Clinton and U.S. officials threatened retaliatory measures should the EU fall to approve the merger." (Karpel, 1998). Resolutions passed in both the White House and Senate vowed that any disapproval by the EC of the merger "would constitute an unwarranted and unprecedented interference in a United States business transaction that would threaten thousands of American aerospace jobs." (Roberto, 1998).

Political ties and strong backing
The merge in 1997 triggered strong political tensions between Europe and the USA: Boeing had unquestionable and unprecedented political backing, including strong ties with the US government and US Department of Defense/The Pentagon. In 2003 Boeing's revenue from Pentagon contracts have surpassed its commercial plane sales: about $27 billion versus $22 billion (Los Angeles Times, 2003).

Exports of aircraft have been very important to the U.S. economy. Within two years of the merger, it has been decided to move Boeing's headquarters from the historical Seattle premises to new premises in Chicago, while thousands of engineers remained in Seattle (Fig. 7). Boeing's managers emphasized new strategy focused on "developing global growth opportunities" and listed 19 criteria when choosing the new headquarters (Harvard Business Review, 2001).

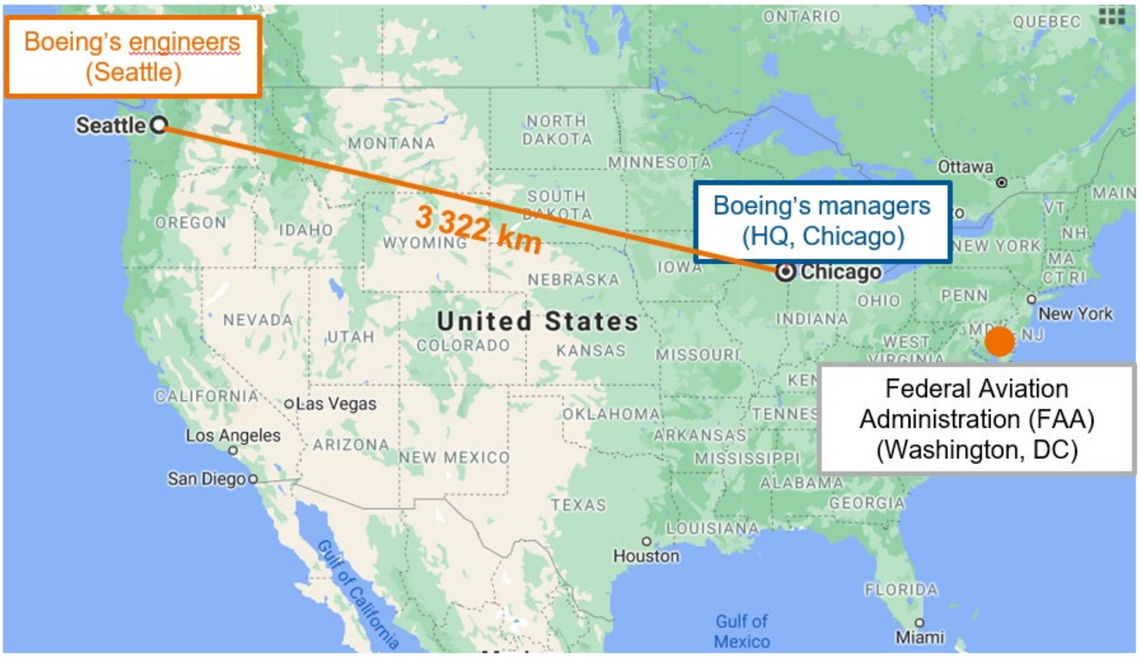

Figure 6. Illustration of Boeing's headquarter move.

Ripple effects of the big moves: The move of Boeing's headquarters from Seattle to Chicago in 2001, with engineers staying in Seattle and managers moved to Chicago have significantly widen the gap

[4] How the McDonnell Douglas-Boeing merger led to the 737 Max crisis — Quartz (qz.com);

between managers and engineers and weakened engineers' ability to participate in decision-making. Effectively, engineers had no voice in decision-making – even when they voiced concerns, they were suppressed by managers. The physical distance turned to a distance in decision-making. Recent research on aviation accidents indicated that power distance and poor listening to safety concerns (safety listening) suppresses safety voice (Noort et al., 2021). As indicated in the background interview, the assumption seemed to be that ”Boeing didn't need senior engineers because its products were mature.”

In 2009 Boeing moved its whole 787 Dreamliner production line from Renton Washington to South Carolina. The motivation behind was that the trade union in Washington was “too strong”, while in fact South Carolina was a "right-to-work" state, e.g. composed of non-unionised, cheap labour. For 20 years (1989–2009) the union has shut down Boeing's commercial aircraft production line four times. In 2008, a 58-day strike by 27,000 machinists at Boeing over outsourcing, job security, pay, and benefits cost the company $1.8 billion.

The **dominant economic institutional logic** manifested also in the Boeing's annual reports (2012–2018): Boeing was preoccupied with efficiency and profitability, and this showed also in the language used in these public records. Safety has mainly been linked to workers safety and ”safety” mentioned sporadically (5–10 times), while ”profit” (36–41 times), ”cash” have been mentioned much more often (125–183 times). Also, on Boeing's web page in the expectations to potential suppliers safety is not mentioned. Management bonus systems could be regarded as a weak signal, too. It was obvious in both cases that decisions causing extra delays or costs were avoided. Bonus system has been an incentive for such decisions.

Worker safety vs. system safety: In both cases the companies were praised for their excellent records on worker safety. This is a weak signal because as indicated by Deepwater Horizon Study Group (2011), the disaster has clearly showed “there are important differences between worker safety and system safety. One does not assure the other.” At BP, meetings have been held with operations personnel to congratulate the crews and organizations for their excellent records for worker safety. In the Boeing's case, on 22 October 2018 the National Safety Council (NSC) presented the Boeing Company with 2018 Robert W. Campbell Award, stating that the “aviation leader finds innovative ways to address common workplace safety issues and protect employees.”

Poor communication and information flow: In both cases the information flow was poor and this allowed for critical information not to be shared, e.g. in Deepwater Horizon testing result from critical testing, such as cementing and negative pressure test, were not informed to MMS, not even to BP. In Boeing 737 MAX case, information about the Manoeuvring Characteristics Augmentation System (MCAS) was not shared with the pilots: Boeing and the FAA did not inform pilots about MCAS in manuals, even though Boeing's safety analysis expected pilots to be the primary barrier in case the system experiences failure. In 2016 Boeing made substantial changes to MCAS' scope and power, but did not submit documentation of the revised system safety assessment to the FAA. In turn, FAA have informed that the safety agency did not require a new system safety analysis because it was not considered to be critical (Seattle Times, 2019).[5]

In the Deepwater Horizon case, warnings on backup systems for oil rigs sounded 10 years before the accident but MMS left it up to the companies to decide what kind of backup system to have (if any). “The MMS considers a backup BOP actuation system to be an essential component of a deepwater drilling system, and therefore expects operators to have reliable back-up systems for actuating the BOP.” However, despite the notifications by third-party reports, elaborated earlier, MMS had mainly “expectations” to the industry and did not act accordingly to verify the decisions and activities as an independent and proactive regulator should do.

[5] https://www.seattletimes.com/seattle-news/times-watchdog/the-inside-story-of-mcas-how-boeings-737-max-system-gained-power-and-lost-safeguards/

6. Lessons learned and implications for the nuclear industry

The objective of this study was to analyze the institutional factors related to the Boeing 737 MAX and Deepwater Horizon accidents to provide STUK and the nuclear industry with relevant lessons and insights for the regulatory safety oversight and overall operations.

Both accidents happened in major industrial domains, which are marked by complex political, economic and governmental interests. Oil and gas and aviation domains have been especially lucrative and profitable industries, critically important for the national economies. The long track records of success in the operators as highly respected companies had grown into tick and deeply rooted complacency, paired with strong political support, beliefs in the engineering excellence, which affected decision-making and operational safety oversight.

Lessons learned and relevance for the Finnish nuclear industry can be summarized as a set of insights and questions for the regulator and industry to pay attention to in order to ensure that safety is not compromised, especially in light of technological development and critical changes:

1) **Role of national government and political power** in potentially affecting safety decision-making of the regulator and industry. In Finland traditionally there has been high trust in institutions that they are doing best for the industry and society as a whole. In general, politics involves handling inherently conflicting interests, and as indicated in the two cases, if allowed, the industry may not hesitate formal and informal lobbying to gain legitimacy. In the cases, the economic institutional logic gradually became dominant over the engineering logic since the developments in aviation and oil & gas have been seen as especially important sectors for the prosperity of the US economy. Culture of exclusivity, combined with strong political backing and iconic, long-term engineering excellence formed fertile ground for executives' complacency.
2) **The importance of independent regulator:** In both cases there were evidences of conflicts of interest and compromised independence of the regulators. For example, it was unwritten code of conduct that the regulator does not interfere with the operator's business since they know best and can decide for themselves. All actors, including the authorities, have been acting in a way to advance the interests of the industry. The independence of FAA as a regulator was missing – in essence, the ODA program gave companies such as Boeing unprecedented authority to certify the airworthiness and the safety of their own planes. In the Deepwater Horizon case, the double role of MMS was a conflict of interest – acting as a regulator and also collecting royalties from the companies – which was tolerated and encouraged for decades by the federal government, and thus institutionalized. The regulator needs to be independent, to show courage and confidence to interfere when needed. Coaching regulatory style needs to co-exist with controlling the industry. How close is too close, when and how blurred boundaries may become institutionalized?
3) **Resources and competences of regulator** to conduct audits. What if there is a huge need for certification and oversight if many new SMRs for example become possible to be built in Finland, in parallel with the oversight conducted for the current operational NPP units and also for Hanhikivi1 NPP? What if the law changes and oversight and certification can be outsourced to individuals and consultants in large amounts? How to ensure the competences of the regulator is not outdated as the technology is developing rapidly? How to ensure there are sufficient resources both in terms of HR and proper incentives for high quality work of the regulator?
4) **Decision-making power and capabilities of both regulator and companies**: how to ensure there is trust and timely, open information flow and constructive communication to ensure information is fully available and decisions can be made accordingly from the right groups of people? How to make sure the managerial, executive power does not silence the voice of engineers on safety matters, that is, that leadership for safety is executed professionally and continuously rather than leadership for reputation and profitability? Marginalization of engineers and as a consequence shifting their role and decision-making power from central to peripheral was observed

in the Boeing 737 MAX case. The power of executive leadership was much stronger than the power of senior engineers, and this was toxic for safety.

5) **Safety vs. profit tension:** there is a need to observe long-term safety effects of structural issues (changes of HQ and production facility (Boeing), engineers placed under project management (BP); decision-making processes (e.g. how safety concerns are addressed in the company); dominant logic in the industry and its wider business environment – what if the nuclear company is a part of a bigger organization where nuclear business is in a minor role, how to keep safety in focus?

6) **Mergers of organizations, as well as outsourcing** are potentially critical changes, which can have safety consequences years or decades later: mergers need close attention and monitoring by the regulator to assess changes in the culture, risks, power balance, decision-making and interface between executives and senior engineers. Boeing-McDonnell Douglas merge happened 20 years before the accidents; there have been mergers also in Deepwater Horizon key organizations.

7) **Poor communication and lack of information sharing**: in both cases site operators / pilots were not even informed about the system modifications. The motivations have been largely economical (financial incentives, saving time but also based on false assumptions that the changes made are not safety critical) – if this has been acknowledged, the companies should have paid a lot more for training, proper certification, etc. Boeing's pilots noted the problems, safety concerns were raised but downplayed. Human factors requirements should be as hard as technical requirements. How to ensure openness, transparency and timely sharing of information between the operator/licensee and the regulator?

8) **"Fortress" mentality and the role of educational institutions**: in Finland there has been long-standing trust in education, and especially engineering education. In the USA, aerospace engineering departments accept the best candidates and the competition is fierce; also the importance of MBA degree as a ladder to high level executive positions is well known. Such educational background gives strong legitimacy. Attractiveness of nuclear industry – compared to other sectors – is an important factor for students and younger experts when planning careers. The effects of the institutional isomorphism refer to experts trained in the same or very similar educational backgrounds, who may approach problems in much the same way and can potentially lead to certain "blindness". Experts in the nuclear industry may circulate from companies to the regulator, to universities, research institutes and back – such inter-hiring also may lead to isomorphism. A relevant question is how Finnish experts in the nuclear industry can challenge each other to stay vigilant? The "fortress" mentality might also be a positive thing if we consider that everyone in the nuclear industry aim at safe nuclear operations.

9) **Gradually losing sight at operational safety**: in both cases, the companies have been blinded by taken-for-granted engineering excellence, strong profit and positive worker safety records. Product vs. process safety – international competition with Airbus triggered strong focus on certification of the product instead of organizational processes and relations with the regulator; Worker safety vs. process/operational safety – awarding the companies for excellent worker safety shifted the attention from operational safety issues; Long complex supply chains contributed to gradual loss of competences and impossibility to understand the big picture.

As a regulator, STUK is facing changes in the nuclear domain in the future, and this may require changes in the way regulatory oversight is done. There is a need to monitor the long-term safety effects of critical decisions and changes. Although weak signals can be identified in the institutional context, often there are organizational biases and power aspects in signals interpretation and acting upon. This is especially challenging when potential future impact realizes decades later, combined with other factors, such as inter-organizational issues. The results of this study are expected to support the regulator's risk-informed oversight and operations, as well as the nuclear industry organizations and inter-organizational relations from an institutional perspective.

References

BOEMRE (Bureau of Ocean Energy Management, Regulation, and Enforcement) (2011). Report Regarding the Causes of the April 20, 2010 Macondo Well Blowout. Available online at www.boemre.gov/pdfs/maps/dwhfinal.pdf.

BP (2010). Deepwater Horizon. Accident Investigation Report. Summary available at deepwater-horizon-accident-investigation-report-executive-summary.pdf (bp.com)

Boeing Annual Reports (2012-2018) Boeing Company - Investors - Financial Reports

Canadian Nuclear Safety Commission (2020). Annual report 2019–2020. ISSN: 1912–0753, Government of Canada Catalogue Number: CC171E-PDF, Published by authority of the Honourable Seamus O'Regan, P.C., M.P., Minister of Natural Resources.

Chief Counsel (2011). Macondo: The Gulf Oil Disaster. Chief Counsel's Report, National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling. Available online at https://permanent.fdlp.gov/gpo4390/C21462-407CCRforPrint0.pdf

CNN (2010). MMS was troubled long before oil spill - CNN.com

Davis, D. (2012). Lessons Unlearned: The Legal and Policy Legacy of the BP Deepwater Horizon Spill, 3 Wash. & Lee J. Energy, Climate & Env't. 155 (2012), https://scholarlycommons.law.wlu.edu/jece/vol3/iss2/2.

Deepwater Horizon Study Group (2011). Final Report on the Investigation of the Macondo Well Blowout, 126 pages. http://large.stanford.edu/courses/2011/ph240/mina1/docs/DHSGFinalReport-March2011-tag.pdf

Dufva, M. (2019). What is a weak signal? https://www.sitra.fi/en/articles/what-is-a-weak-signal/, SITRA, The Finnish Innovation Fund.

Dunn, M. B. and Jones, C. (2010). Institutional logics and institutional pluralism: The contestation of care and science logics in medical education, 1967–2005. Administrative Science Quarterly, 55, 114–49.

DW (2011). Airbus wins big with American Airlines | Business | Economy and finance news from a German perspective | DW | 21.07.2011

ECONOMIST (1997). Boeing v. Airbus: Peace in Our Time, Aug. 1, 1997, at 59, 61. First 737MAX, 'Spirit of Renton,' makes first flight | Renton Reporter

Friedland, R. and Alford, R. R. (1991). Bringing society back in: Symbols, practices and institutional contradictions. In Powell, W. W. and DiMaggio, P. J. (Eds), The New Institutionalism in Organizational Analysis. Chicago: University of Chicago Press, 232–63.

Greenwood, R., Oliver, C., Sahlin, K. and Suddaby, R. (2012). *Institutional Theory in Organization Studies*. London: SAGE.

Greenwood, R., Raynard, M., Kodeih, F., Micelotta, E. R. and Lounsbury, M. (2011). 'Institutional complexity and organizational responses'. The Academy of Management Annals, 5, 317–71.

Harvard Business Review (2001). Inside Boeing's Big Move (hbr.org)

Herkert, J., Borenstein, J. and Miller, K. (2020). The Boeing 737 MAX: Lessons for Engineering Ethics. Science and Engineering Ethics volume 26, pp. 2957–2974 https://link.springer.com/article/10.1007/s11948-020-00252-y

Jong, W. and Broekman, P. (2021). Crisis history and hindsight: A stakeholder perspective on the case of Boeing 737-Max. Public Relations Inquiry, 10(2), 185–196. https://doi.org/10.1177/2046147X211001350

Karpel, A. (1998). The European Commission's Decision on the Boeing-Mcdonnell Douglas Merger and the Need for Greater U.S.-EU Cooperation in the Merger Field." American University Law Review 47, no.4 (February 1998): 1029-1069.

Levin, B. (2019). 737 report: Boeing trained 737 MAX pilots on IPADS to save cash. Vanity Fair, March 18. Retrieved January 16, 2020 from https://www.vanityfair.com/news/2019/03/boeing-trained-737-MAX-pilots-onipads-to-save-cash.

Meyer, J. W. and Scott, W. R. (1983). Centralization and the legitimacy problems of local government. In J. W. Meyer & W. R. Scott (Eds.), Organizational environments: Ritual and rationality (pp. 199–215). Beverly Hills, CA: SAGE.

NASA (2011). Academy Case Study: The Deepwater Horizon Accident Lessons for NASA, May 10, 2011 Vol. 4, Issue 3, available at Academy Case Study: The Deepwater Horizon Accident Lessons for NASA | APPEL Knowledge Services

National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling. (2011). Deep Water: The Gulf Oil Disaster and the Future of Offshore Drilling. Report to the President. Available online at https://www.govinfo.gov/content/pkg/GPO-OILCOMMISSION/pdf/GPO-OILCOMMISSION.pdf

North, D. (1990). *Institutions, Institutional Change, and Economic Performance*. Cambridge: Cambridge University Press.

NRC (2018). NSC Presents the Boeing Company with 2018 Robert W. Campbell Award - National Safety Council

Office of Inspector General (2015). FAA Lacks an Effective Staffing Model and Risk-based Oversight Process for Organization Designation Authorization, Federal Aviation Administration Report Number: AV-2016-001 Date Issued: October 15, 2015, Audit Report, FAA Lacks an Effective Staffing Model and Risk-Based Oversight Process for Organization Designation Authorization (dot.gov)

Office of Inspector General (2021).Weaknesses in FAA's Certification and Delegation Processes Hindered Its Oversight of the 737 MAX 8 U.S., February 23, 2021, Audit Reports /AV2021020, Department of Transportation. Audit Reports | Office of Inspector General | U.S. Department of Transportation (dot.gov)

Pache, A.-C. and Santos, F. (2013). Inside the hybrid organization: Selective coupling as a response to competing institutional logics. Academy of Management Journal, 56, 972–1001.

Quartz (2020). How the McDonnell Douglas-Boeing merger led to the 737 Max crisis — Quartz (qz.com)

Roberto, S. (1998). The Boeing/McDonnell Douglas Merger Review: A Serious Stretch of European Competition Powers, 24 Brook. J. Int'l L. 593. Available at https://brooklynworks.brooklaw.edu/bjil/vol24/iss2/

Scott, W.R. (1995). *Institutions and Organizations*. Sage, Thousand Oaks, CA.

Scott, W.R. (2001) *Institutions and Organizations*. 2nd Edition, Sage, Thousand Oaks

Sgobba, T. (2019). B-737 MAX and the crash of the regulatory system. Journal of Space Safety Engineering, Volume 6, Issue 4, December 2019, Pages 299–303

Shapiro, S. (2007). An Evaluation of the Bush Administration Reforms to the Regulatory Process. Presidential Studies Quarterly, 37(2), 270-290. Retrieved August 30, 2021, from http://www.jstor.org/stable/20619317.

Simply Flying (2020). 100 Years Of History: The Federal Aviation Administration - Simple Flying).

The House Committee on Transportation and Infrastructure (2020). Final Committee report. The design, development and certification of the Boeing 737 Max. September 2020. https://transportation.house.gov/imo/media/doc/2020.09.15%20FINAL%20737%20MAX%20Report%20for%20Public%20Release.pdf

Transocean (2011). Macondo Well Incident. Transocean Investigation Report Vols. I and II (Appendices). Available online at www.deepwater.com/fw/main/Public-Report-1076.html.

U.S. Chemical Safety and Hazard Investigation Board Investigation Report (2010). Drilling Rig Explosion and Fire at The Macondo Well, Deepwater Horizon Rig Mississippi Canyon 252, Gulf of Mexico Key Issues: April 20, 2010. Volume 4 Regulatory Oversight of U.S. Offshore Oil and Gas Operations: A Call for More Robust and Proactive Requirements. volume 4 report no. 2010-10-i-os 4/17/2016

U.S. Federal Register (2005). Federal Register :: Establishment of Organization Designation Authorization Program.

Useem, J. (2019). The long-forgotten flight that sent Boeing off course. A company once driven by engineers became a company driven by finance. The Atlantic, November 20. Retrieved January 23, 2020 from https://www.theatlantic.com/ideas/archive/2019/11/how-boeing-lost-its-bearings/602188/.

Verweijen, B. and Lauche, K. (2019). How many blowouts does it take to learn the lessons? An institutional perspective on disaster development, Safety Science, 111, 111-118.

Wall Street Journal (2019). Boeing, FAA and Lion Air Failures Laid Bare in 737 MAX Crash Report, available at https://www.wsj.com/articles/indonesias-report-on-lion-air-crash-blames-boeing-737-max-design-faa-11571991500

Wendel B. (2019). Technological Solutions to Human Error and How They Can Kill You: Understanding the Boeing 737 Max Products Liability Litigation. 84 J. Air L. & Com. 379 (2019). https://heinonline.org/HOL/LandingPage?handle=hein.journals/jalc84&div=22&id=&page=

West Engineering Services, Inc. (2002). Mini Shear Study for U.S. Minerals Management Service. Requisition No. 2-1011-1003. Dec.

West Engineering Services, Inc. (2004). Shear Ram Capabilities Study for U.S. Minerals Management Service. Requisition No. 3-4025-1001. Sept.