

The Conflict of Increased Reliance on Aviation and Environmental Initiatives

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On my honor as a University Student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments

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Introduction

Environmental problems are not solely the result of industrial activity but also stem from the millions of choices that consumers make in their everyday life, including the decision to fly and have goods flow across the globe (Berglund & Matti, 2006). Despite decades of advancement in aircraft technology and flight operations that increase efficiency, emissions from the aviation industry have accelerated in recent years as a result of industry growth faster than any other transport sector (Overton, 2019). Aviation has garnered the attention of politicians and the broader public as a sector relevant to climate change, but sustainable aviation initiatives confront societal and policy actors as well as long-standing institutional regimes and corporations. While important, these sociotechnical interactions make any progress towards net zero emissions in the aviation industry a difficult task.

The issue of sustainability is a wicked problem because it encompasses conflicting worldviews and has unclear objectives, but it is vitally important for the generational survival of humanity (Seager et al., 2012). The wicked problem framework is used to answer the question: How is the aviation industry evolving in response to continued growth that counteracts increased efforts of environmental sustainability? Analyzing sustainable aviation using the wicked problem framework enables a broadened perspective that discusses the shift in attitudes and behavior requisite among the many industry actors, from consumers driving demand to policy actors responsible for regulation. The framework is also used to assess the need for radical change in the use and regulation of aircraft and provide suggestions for achieving this change.

Methods

The complex and significant environmental impact of aviation is established through the results of scientific research studies on emissions and climate change to establish the issue of sustainability as one that is important and urgent. The question “How is the aviation industry evolving in response to continued growth that counteracts increased efforts of environmental sustainability?” is then answered through a literature review on the multitude of mitigation strategies that have been implemented and proposed. The discussion is organized with respect to the stakeholder bearing the cost and responsibility of implementing a given strategy. With regards to industry corporations, the potential for technological and operational improvement of aircraft is reviewed to illustrate the limitations of a technological fix approach. Legislative initiatives are then discussed using policy analysis of government agencies responsible for regulating the aviation industry and a review of how these policies have become increasingly common in discussion. Finally, discourse analysis of published surveys and focus group results is used to analyze public sentiment and to assess the potential for consumer behavior change that mitigates aviation’s environmental impacts. Through researching the various stakeholders, from engineers to regulating bodies and individual consumers, a holistic perspective of sustainable aviation is garnered and the future of the aviation sector with respect to achieving sustainability is discussed.

Increased Reliance on Aircraft and the Resulting Environmental Impact

Over the last few decades, air travel has become less expensive and more accessible in both developed and developing countries. Family vacation, business, and international student travel have become social norms despite air travel historically being an aspiration accessible only

to a minority of wealthy travelers (McDonald et al., 2015). Globally, the number of passengers utilizing air transport doubled from 2000 to 2020 and passenger air miles nearly doubled in the single decade of 2010 to 2020 (Köves & Bajmócy, 2022). Despite a recent and abrupt decline due to the global COVID-19 pandemic, the historic growth pattern is expected to continue for the foreseeable future (Lee et al., 2021). For decades, the industry has been key in maintaining connectedness in the globalized world in terms of business, private travel, tourism and politics (Köves & Bajmócy, 2022). While bringing about considerable economic benefits, growth of the aviation sector is also likely to lead to greater adverse social and environmental impacts.

The growth of the aviation sector and resulting increase in emissions comes at a time when Earth scientists are warning society at large of the dangers of climate change and policy makers are taking notice of the need for increased regulation of the industry (Brewer, 2007). In the United States, the Environmental Protection Agency (EPA) estimates that commercial aviation accounts for 12 percent of total transportation emissions, and at the projected growth rate it is estimated that these emissions may triple by the year 2050 (Overton, 2019). A body of literature continues to grow that indicates air travel and the aviation industry have a significant environmental impact via a complex set of processes. It is well established that international aviation is a significant contributor to global climate change via greenhouse gas emissions resulting from fossil fuel combustion (Becken, 2009; McDonald et al., 2015). In addition to carbon dioxide, emissions of water vapor, nitrogen oxides, sulfate aerosols and increased cloudiness due to contrail formation contribute to aviation's climate impact (Forsyth, 2011). Flying results in the emission of these gasses at high altitudes where research indicates that the contribution to climate change can be several times greater due to sensitivity of the upper atmosphere at flight altitudes (Cowper-Smith & de Grosbois, 2010). A complex set of

atmospheric processes that govern these emissions at altitude act in aggregate to make the environmental impacts of aviation particularly challenging to detect, assess, and model in an accurate manner (Lee et al., 2021).

While greenhouse gasses and carbon dioxide have been a major focus of current research and mitigation strategies, the environmental impacts of aviation extend beyond the emission of greenhouse gasses. Particularly near airports, the industry contributes to local air and noise pollution, and on a global scale, the industry is contributing to biodiversity loss and waste generation, among other social and economic issues (Bauemister, 2020; Cowper-Smith & de Grosbois, 2010). Due to these many complex effects, aviation's contribution to climate change may very well be underestimated and growing in proportion to the industry. As a result, many consider that the current level of reliance on the industry is inconsistent with environmental sustainability (Forsyth, 2011).

Framing Sustainable Aviation as a Wicked Problem

While there has been little research on how issues associated with aviation are being constructed in society and how environmental discussions are shaping policy for sustainable aviation, the general issue of sustainability and the characteristics of environmental problems have been thoroughly analyzed in the study of Science, Technology, and Society (STS) (Walker & Cook, 2009). In STS, sustainability problems are widely recognized using the wicked problem framework, which not only aids in problem characterization and definition, but also enables a broader perspective that represents a necessary shift in the mental modes of individual consumers, commercial organizations, and policy actors (Blok et al., 2016; Seager et al., 2012). The wicked problem terminology was first used by design theorists Rittel and Webber in 1973 to

draw attention to the challenges of addressing planning and social policy problems (Rittel & Webber, 1973). The conceptual connection between sustainability and wicked problems is largely attributable to Norton (2005), who argues that sustainability problems exhibit the ten characteristics that are constitutive of wicked problems. Noteworthy characteristics are that sustainability encompasses conflicting worldviews, is a dynamic problem, has unclear objectives, and has open-ended timeframes (Brønn & Brønn, 2018). Additionally, the relevant stakeholders play a prominent role in wicked problems. Despite abundant literature on the wicked problem framework, questions remain as to what the designation of wicked means and whether the notion offers insight in how to tackle wicked problems in practice (Termeer et al., 2019).

In acknowledging the critiques of the wicked problem framework, certain authors argue that the basis of the framework has been insufficiently examined. In their article, Turnbull & Hoppe (2018) reject the notion of wicked problems on philosophical and practical grounds, saying that the term has become too broadly applied and that the policy sciences already had better conceptualizations of public problems. Stemming from the rhetorical appeal of the concept, the term wicked has been used in different ways and in various contexts, often stretching the concept beyond its original intention and even to the point of alleviating responsibility for policy failures (Peters, 2017). Despite these critiques of the wicked problem framework in general, the concept becomes relevant when the usual bureaucratic and professional means of addressing policy problems start to fail and even critical authors agree that the concept can be considered generative because it has inspired research in many existing, new and interrelated fields (Termeer et al., 2019).

There is little literature directly applying the wicked problem framework to the issue of sustainable aviation. However, sustainable aviation efforts require understanding complex global systems, resolving contrasting value judgments or cultural norms, and relevant knowledge in multiple technical disciplines. These characteristics are all compatible with the framework, similar to how the issue of general sustainability has been treated in general. Issues of sustainable aviation have a range of stakeholders including environmental organizations, airlines, citizens and national governments, all of whom are attempting to frame the issue to suit their own objectives (Walker & Cook, 2009). A key feature of using the wicked problem framework to answer the proposed research question is that there are no unique, clearly best solutions, so using many different viewpoints to address the same issue is of vital importance (Köves & Bajmócy, 2022). Despite the lack of an obvious and optimal solution, a better understanding of the problem can help to facilitate what may be only limited solutions to the proposed research question.

Strategies for Mitigating Environmental Impact

In a society that increasingly emphasizes environmental sustainability, it is clear that the aviation industry will have to mitigate its environmental impact if it is to continue growing in the future as it has in the past. The difficulty in this prospect lies in the fact that there is no obvious and optimal path forward for the many stakeholders. Disconnect arises from a lack of shared understanding between stakeholders, all of whom view aviation's environmental impacts and proposed mitigation strategies with varying motives and perspectives (Walker & Cook, 2009). While the role of the industry and government in the mitigation process has been discussed widely in literature, the role of individual air passengers has received far less attention even though behavioral change among consumers may be the mitigation measure with the greatest

potential (Baumeister, 2020; Kantanbacher et al., 2018; Cohen & Higham, 2010). As is inherent in wicked problems, nested and dynamic relationships exist between stakeholders and consumer behavioral change cannot solve the issue single-handedly. Only in an integrated and cooperative way, focused on resolving the perspective differences between stakeholders, is it possible to limit the contribution of the aviation industry to climate change and achieve sustainable growth in the long run.

Sustainable aviation is emerging as a developing field that attempts to account for the social, economic, and environmental impacts of aviation (Walker & Cook, 2009). Focusing on environmental sustainability, the current literature has discussed five overarching strategies for the mitigation of environmental impacts. These are technological changes, market-based changes, operational changes, regulatory changes and behavioral changes (Baumeister, 2020). Initiatives proposed by key corporate members within the aviation industry rely heavily on technological change, while the industry's need to grow remains unquestioned (Köves & Bajmócy, 2022). The approach of the aviation industry as an economic actor tends to be self-serving, while governments tend to take a more balanced approach that emphasizes the economic benefits of the sector but also aims to address the environmental impacts that may arise from its continued growth (Walker & Cook, 2009). Government bodies can implement market-based changes, such as taxes, in addition to implementing regulatory change pertaining to the development and certification of new aircraft technologies (Baumeister, 2020). Despite relatively new and earnest pleas from international governments to avoid unnecessary flying, policy initiatives still tend to favor growth of the industry in the short to medium term, thus placing the decision to fly or not directly with the individual consumer (McDonald et al., 2015).

In recent years, there has been a shift from climate change being conceptualized as a macro scale problem resulting from large industries to one which relies on the individual consumer to mitigate (McDonald et al., 2015). While literature continues to grow surrounding increased consumer awareness of climate change issues, the fact remains that there are few signs of behavioral change amongst even the most environmentally aware travelers (McDonald et al., 2015). The mitigation strategies broadly discussed here serve to highlight how the aviation industry lies at the intersection of the competing interests of safety, economics, performance and environmental impact. The issue of sustainable aviation is heavily contested and different groups are attempting to reframe it to suit their own objectives.

The solution of wicked problems like sustainable aviation requires a multi-disciplinary approach that can bring together disparate perspectives in a way that is adaptive, participatory and transformative (Sun & Yang, 2016). There is no solution that satisfies all stakeholders, but a better understanding of the problem and multitude of ways it could be solved can help to facilitate what may be only limited, realistically feasible answers (Peters, 2017). In discussing potential solutions, it is important to keep in mind that the complexity of climate change and aviation's environmental impacts are not yet fully understood (Sun & Yang, 2016). It is also vital to be aware of the bounded rationality of any proposals. For instance, halting all air travel would certainly reduce the industry's environmental impact, but few would consider that a reasonable solution. The properties of sustainable aviation as a wicked problem shed light on the usefulness of the famed systems approach for treating wicked problems, whereas at present, solutions often place the responsibility and cost on a single stakeholder. In the following section, current initiatives and proposals for achieving sustainable aviation will be discussed in terms of the stakeholder that bears responsibility and initial costs. The aim is to see why hesitation arises over

implementing sustainable aviation strategies and where agreement can be found between stakeholders.

Technological and Operational Change

Corporate organizations like airlines and airport authorities bear the responsibility of implementing technological and operational changes. Stemming from the promise of maintaining the current social and economic status-quo, much of the existing research on sustainable aviation has a positivistic focus on technological developments and more efficient operations (Köves & Bajmócy, 2022; Walker & Cook, 2009). Using alternative fuel sources, new materials, improved design, and hydrogen or electric propulsion systems all have the potential to mitigate environmental impacts, but many of these technologies are still in their infancy (Adler & Gellman, 2012; Lee et al., 2021). New technologies will play a role in advancing sustainable aviation, but it is difficult to predict when they will become technically feasible or economically viable (Forsyth, 2011). Thus, environmental problems will not be solved by technological fixes alone, and focus has shifted to other solutions in recent years (Kantenbacher et al., 2018). Operational changes reduce the inefficiencies in the operation of existing aircraft on the ground and in the air. The Intergovernmental Panel on Climate Change (IPCC) found that improvements in air traffic control of flight patterns could reduce aviation fuel consumption by around 10%, but this would require major organizational changes and greater collaboration between fragmented management systems (Baumeister, 2020). Other operational changes include improving taxi operations and reducing emissions of ground handling equipment. Despite these numerous and varied efforts, expansion in aviation is on track to outpace any technological and operational improvements (Köves & Bajmócy, 2022; Walker & Cook, 2009).

Even with the limited prospects of these two mitigation strategies, society must be fully aware that such strategies prioritize profit over environmental interests (Köves & Bajmócy, 2022). Across industries for which climate change is a relevant problem, there is widespread reluctance among corporations to exchange the profit-oriented business model for one that is tied to environmental processes. In a market-driven capitalist economy, organizations like airlines and airport authorities are hesitant to move beyond conventional revenue maximizing and shareholder value perspectives, because doing so would lead to insurmountable financial losses, layoffs, and hostile takeovers (Köves & Bajmócy, 2022). However, according to Cowper-Smith and de Grosbois (2010), “there is a growing public expectation that corporations should recognize their social and environmental responsibilities towards society and improve the sustainability of their operations.” Cowper-Smith and de Grosbois (2010) identified specific corporate social responsibility initiatives implemented in the airline industry and their level of adoption. Their findings indicate that airlines are responding to increasing concern among the public and want to demonstrate that they care about the environment. Perhaps of greatest concern with these initiatives is the idea that even if supply-side efficiencies can be achieved, these may serve only to stimulate increased demand that cancels out any improvements in environmental performance (Walker & Cook, 2009).

Market-Based and Regulatory Change

Over the history of the aviation industry, both airlines and airports have been heavily regulated and subsidized (Adler & Gellman, 2012). Market-based changes such as taxes, charges, subsidies and emissions trading are all well-established policy tools that represent avenues to new solutions (Baumeister, 2020). Among other purposes, these market-based

policies can be targeted at reducing demand from consumers, incentivizing emissions reduction, or generating tax revenue that can be used to offset emissions elsewhere through research and investment. One market-based approach that has received particular attention in recent years is emissions trading. In this scheme, emissions limits are set and allocations are granted that can be traded by the components of a system. Many countries, including those of the European Union, the United States, and China, have implemented this approach across industries from energy production to manufacturing, but aviation is still largely yet to be a target of this scheme. Alternatively, charges and taxes on emissions can be used to generate revenue for incentivizing public researchers and private corporations to explore new ways of reducing greenhouse gas emissions. On the regulatory side, agencies like the Federal Aviation Administration (FAA) in the U.S. have focused on engine certification and imposing limits on the emissions of newly manufactured engines (Baumeister, 2020). Despite the multitude of policy tools at legislator's disposal, there has been little substantive action to date across the world's governmental bodies due to the international perception of aviation as a key enabler of the global economy (Kantenbacher et al., 2018).

When compared to the energy and automotive sectors, aviation has been identified as the most difficult for implementing sustainability in policy formulation due to both the direct clash between environmental and economic policy and because of the lack of sustainable alternatives to transition to (Kantenbacher et al., 2018). There has been little initiative among policy makers to control aviation emissions due to concerns about the economic consequences that would result. The approach of governments is often called "balanced," whereby the imperative of short-term economic growth is weighed against the mitigation of localized and global environmental impacts (Walker & Cook, 2009). This is largely a rhetorical strategy used to justify the short to

medium-term expansion of the industry while neglecting the environmental impacts as a problem for future generations (Walker & Cook, 2009). Additionally, aviation is an industry that crosses countries and continents which makes any policy-based approach geographically limited and challenging to enforce due to divergent political interests.

Behavioral Change

Consumers today find themselves in an unenviable position, caught between the competing ideals of environmental responsibility and the perceived personal benefits of socially embedded air travel norms (McDonald et al., 2015). Shaw and Thomas (2006) identify air travel as a classic example of the tragedy of the commons, whereby reducing personal benefits for the greater good is perceived as useless unless others do the same. Even self-identified environmentally conscious consumers are resistant to the prospects of flying less or paying for optional carbon offsets (McDonald et al., 2015). Through a review of various consumer studies, it is evident that passenger demand will not subside as a result of concern over aviation's environmental impact (Cohen, 2010; Davison et al., 2014; Kantanbacher et al., 2018; McDonald et al., 2015). When it comes time to fly, factors such as price, convenience, quality, and habit often outweigh environmental considerations for most consumers (Dauvergne & Lister, 2010).

Though several authors believe that behavioral change may be the measure with the greatest potential for mitigating environmental impact, it has received far less attention in literature than those measures previously discussed (Davison et al., 2014; Gössling, 2020; Baumeister, 2020). Literature on behavioral change tends to focus on taking fewer flights, reducing the distance traveled, staying longer at destinations, and choosing more sustainable modes of transportation (McDonald et al., 2015). The strategies discussed here are certainly

ways to reduce environmental impacts, but alternatives that focus on mitigation by the way in which people fly rather than whether to fly may be more widely accepted (Baumeister, 2020). In democratic countries, consumers that fly are also the citizens that hold the power to vote for legislation and legislators in support of policies for sustainable aviation. In their results from a quantitative online panel survey, Kantanbacher et al. (2018) find that consumers generally support policies that address the climate impacts of flying, albeit policies that impose the costs of mitigation on the aviation industry or governments.

Eco-consumerism is a concept that revolves around using individual consumer purchasing power to bring about a transformation to sustainable consumption and an environmentally conscious economy without the need for inherently restricting travel freedoms (Dauvergne & Lister, 2010). The basic principle is for consumers to induce market changes using their purchasing power as leverage in a competitive market, essentially voting for and supporting eco-friendly companies and products. This strategy is reliant upon information from airlines that is freely available and easy to understand. Literature indicates that consumers are requesting such information, but standardization in reporting practice is required in order to allow for proper comparison between companies (Cowper-Smith & de Grosbois, 2010; Baumeister, 2020).

Just like the industry and government actors, consumers are reluctant to voluntarily bear the responsibility and cost of ensuring the mitigation of environmental impacts despite being aware of the destructive environmental effects of unabated growth of the industry. To counteract this value-action gap, initiatives should take explicit account of the fact that consumer behavior needs to be viewed in a societal context rather than at the level of individual decision making (Becken, 2009). Individual ethical norms certainly guide decision making, but institutions

prevailing in society affect these norms and are amenable to change (Berglund & Matti, 2006). Based on the results of in situ focus groups of international tourists, Becken (2009) suggests that only major changes on a societal level would be sufficient to drive the behavioral change needed to reduce air travel's environmental impact. This points to the requirement for structural strategies, in addition to informational strategies designed to increase awareness of the issue of aviation's climate impact among the public (Davison et al., 2014).

Disparate Perspectives and Ways Forward

There is a current disharmony between how consumers, industry, and policy makers view air travel (Davison et al., 2014). As businesses, industry actors are unwilling to voluntarily invest in sustainable changes or are unable to overcome technological barriers. Policy makers have handed the responsibility of mitigation to consumers for fear of economic consequences of strict regulation. Consumers, as evidenced by multiple surveys, believe that the responsibility for aviation emissions should sit with industry and policymakers, rather than the public (Kantenbacher et al., 2018). Among the stakeholders, there is a wide attribution of responsibility for aviation's environmental impacts, and each is responding to the problem based on a limited, bounded, and somewhat inconsistent view (Sun & Yang, 2016). Put simply, the primary reason for historically limited progress in sustainable aviation is that airlines want to maximize profits, consumers want to maximize financial and social freedom, and governments' primary concern is with the economy. Acting alongside these differences in perspective, the impossibility of understanding the full repercussions of the environmental impacts and the consequences of each mitigation strategy makes many of the stakeholders hesitant to move forward with implementing strategies and proposing alternatives (Sun & Yang, 2016). Even still, none of the previously

discussed initiatives or proposals, if fully adopted, will single-handedly solve the issue of aviation's climate impact. With this discussion, it may seem as though the possibilities of attaining sustainable aviation are bleak, in part, because the relevant stakeholders have been working independently for the sake of their own interests and without seeking understanding and compromise.

The conflict of increased reliance on aviation and environmental impacts is an excellent example of collective denial, where stakeholders are waiting for the others to take both responsibility and initiative (Becken, 2009). This leads to the idea that no single stakeholder should bear the cost or responsibility for mitigation, which is rather contrary to the strategies discussed thus far. The challenge remains, however, in establishing a suitable compromise between stakeholders that can address the social, economic, political, and scientific complexities that make achieving sustainable aviation such a difficult, but incredibly important, problem to solve. As a first step, this will require a new paradigm able to objectively explain the complexity of the problem that has, until now, been framed from the perspective of individual stakeholders (Sun & Yang, 2016). Only then, with a better understanding of the true nature and scope of the complex relationships, can the requisite innovative approaches to governance and institutional frameworks be implemented. For this to happen, radical changes are necessary in terms of measuring economic activity, the progress and potential of technology, and the limits of sustainable transitions created by rapid growth (Gössling & Higham, 2020).

There is a significant absence of discussion in the literature on alternative pathways to the mitigation strategies hitherto discussed, which tend to be framed in almost entirely economic terms. A key aspect of the reluctance to implement mitigation strategies is a reluctance to exchange a profit-oriented business model and financial, market-based economy for ones that are

more closely tied to environmental processes (Sun & Yang, 2016). He (2014) argues that a new economic model integrating ecological modernization and sustainable development offers “win-win scenarios,” but that the realization of such a model has been hindered by the discursive failures and disagreements on the part of many stakeholders. Such a prospect can only be achieved by abandoning old approaches and past patterns and including the possibility of reorienting and shrinking the global air transport system (Gössling, 2020). Thus, a potential starting point in the discussion of achieving sustainable aviation is formulating and answering the question of how much air transport is necessary.

Limitations and Future Work

It is important to acknowledge there is a multitude of cultural and political differences across countries that makes the issue of sustainability difficult to address on a global scale and the lack of a comprehensive discussion on this point is a current limitation of this work. Much of the literature reviewed in this paper is written by authors from western, democratic countries, rather than approaching this issue on a global scale. It is also important to note that the environmental impacts of aviation are still being uncovered and quantified, so making an argument based on these impacts can be controversial and should be continuously reassessed. Finally, societies are diverse and quickly evolving systems where public opinion on sustainability has changed rapidly over the past decade. The literature on sustainability, as it pertains to aviation, is still relatively sparse and so the general concept of sustainability as discussed in literature has been used where a more specific contextual definition may be required.

Discussion of the limitations of the current work draws attention to the need for further research that would lead to a more thorough assessment and allow for more concrete suggestions to the problem at hand. At the foundation of the need for this research, it is important to continue investigating the true extent of environmental impacts of aviation using quantitative methods that are objective and scientifically based. Much of the literature focuses on emissions reduction, specifically carbon dioxide, but truly sustainable aviation includes a more comprehensive approach that accounts for all emissions and other impacts such as noise and waste. Additionally, in trying to formulate a suggested approach to mitigation, it would be insightful to focus further efforts on understanding how the social, cultural and political norms at a regional or even local community level influence public opinion as opposed to a more generalized approach as taken in this paper. Finally, the discussion of policy initiatives, which have been limited to date, could be elaborated upon with more thorough policy analysis focused on the proposals that have not been implemented to date but are being considered and debated.

Conclusion

There are inherent conflicts between increased reliance on aviation and environmental impact mitigation that must be overcome if the industry is to continue growth in the future as it has in recent decades. While the economic significance and international importance of the industry should not be discredited, a sustainable aviation industry is increasingly desirable and is one in which the various environmental impacts can be understood and accounted for. There is widespread hope for technological solutions, but their impact is often overstated and used to maintain the impetus of business-as-usual approaches. As a promising way forward, consumer behavior change can initiate and drive market change and legislative action, but they can't

directly solve the issue alone. This discussion has revealed a wide attribution of responsibility for aviation's climate impacts that is compounded by considerable differences in perspective among the stakeholders about the implementation of potential mitigation strategies. In order to comprehensively tackle the issue of sustainable aviation, structural strategies alongside social change are required, and a possible reorientation of the industry that includes shrinking of the global air transport system should not be excluded from discussion.

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