Agenda Item: C.6.13* | WORKING PAPER | WP No: 159 IFATCA'25

Contrail Avoidance Strategies

Presented by PLC and TOC

SUMMARY

The last couple of years has seen an increased interest in non-CO_2 emissions from aviation, with a particular focus on persistent contrails. There is consensus among scientists that persistent contrails have a net warming effect. This has led to increasing pressure to implement contrail avoidance strategies to reduce atmospheric warming. The capability to forecast regions that will lead to persistent contrails forming is not yet mature enough to allow for avoidance strategies to be completed accurately. The differing atmospheric warming temporal scales of persistent contrails and CO_2 also present a challenge in terms of which to prioritise.

1. INTRODUCTION

1.1. The environmental issue of persistent contrail formation from aviation has been a significant area of research and discussion in recent years. The discussions and pressure to implement mitigation strategies is growing with many organisations calling for a rapid implementation of Contrail Avoidance Strategies to reduce the warming impact of aviation.

1.2. The European Commission has updated regulations on the monitoring, reporting and verification of greenhouse gases from aviation to include non-CO_2 emissions (specifically for contrails and NOx) (European Commission,2024). The regulations came into force from January 2025.

1.3. There are still uncertainties and a lack of data to support the implementation of these mitigation strategies.

2. DISCUSSION

2.1. The emissions of H_2O and soot particles from aircraft engines aid in the formation of contrails. Many contrails are short lived (those that dissipate in a matter of minutes), but some may persist for hours. Short lived contrails have a negligible effect on warming; however, persistent contrails and contrail cirrus present the largest net warming effect.

2.2. Contrail Avoidance Strategies when implemented will see aircraft routed around areas that are forecast to create persistent contrails. Of the persistent contrails that are formed, only 2% lead to over 50% of the warming, these have been termed "big hits" (Sausen et al. 2023). Persistent contrails are formed when an aircraft passes through an ice supersaturated region (ISSR), and these can later evolve into contrail cirrus. ISSRs are portions of airspace which have in excess of 100% relative humidity with respect to ice (Sausen et al. 2023). Lee et al. (2021) have shown that contrail cirrus (persistent contrails) have a net warming effect on the earth's atmosphere. Most of the warming effect occurs from the evening into the night as the earth radiates heat energy back into the atmosphere and the contrail cirrus acts as a blanket and traps the heat in the atmosphere (Lee et al., 2021) (Fig. 1). Lee et al. (2021) reports that the confidence levels around the magnitude of the warming effect from persistent contrails are low. The current level of research shows that persistent contrails have a net warming effect, but scientists are unsure of how much persistent contrails are expected to warm the atmosphere.

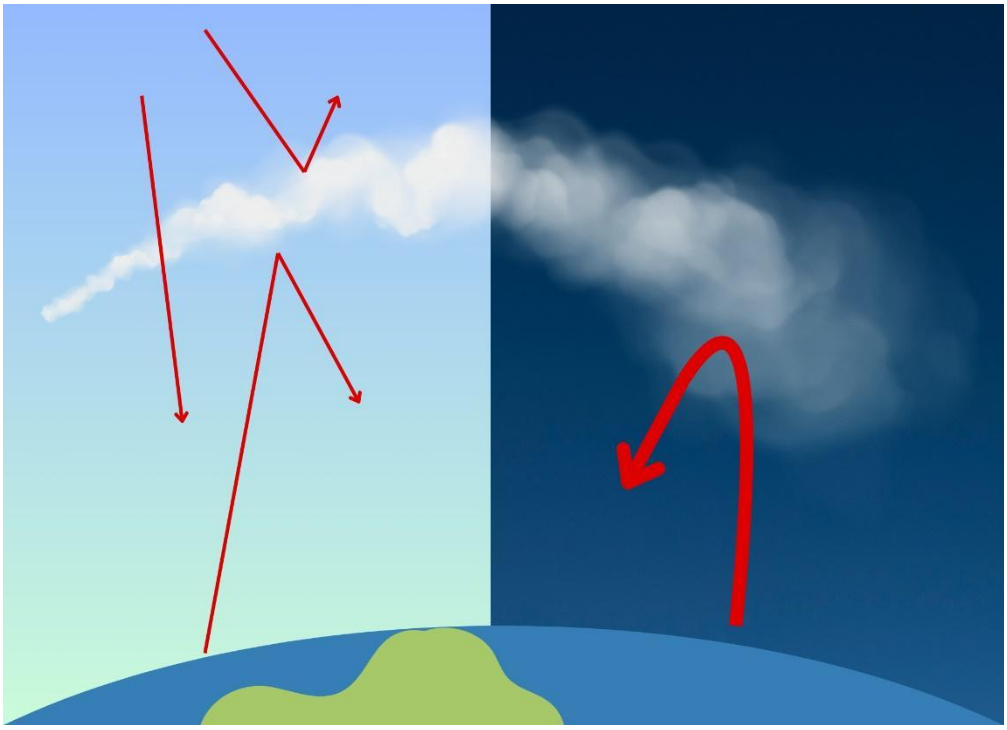

Figure 1: Persistent contrails net radiative effect during the day and night

2.3. A study by Dickson et al. (2009) on the vertical scale of ISSRs found that 81 to 87 percent of the layers were less than 1500m deep, with 27 to 34 percent less than 100m deep. The remaining layers were up to 4500m deep, with 11 percent between 1500m and 3000m deep (Fig. 2).

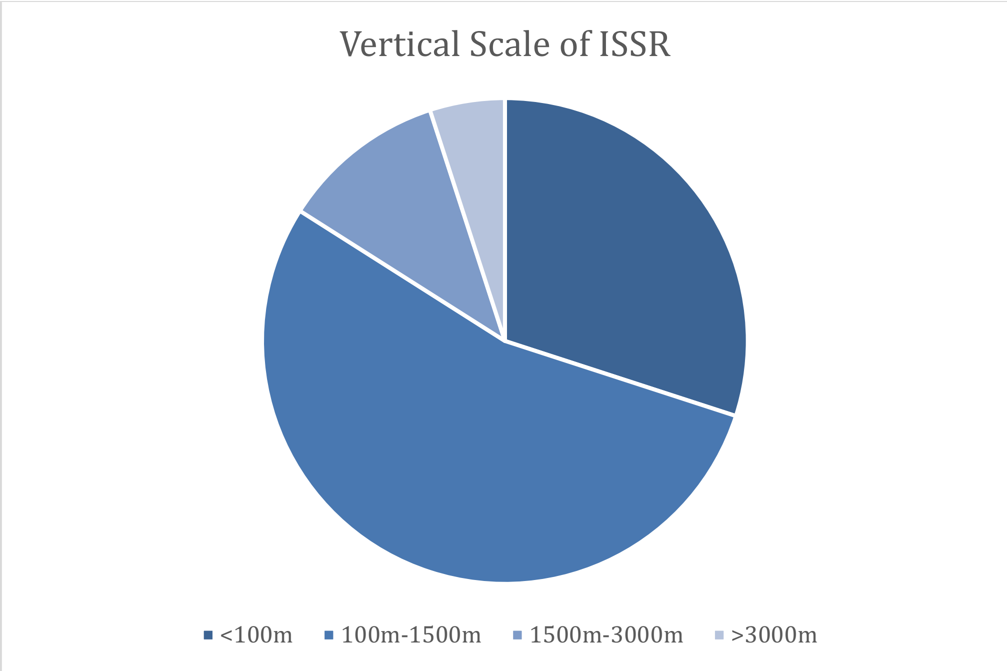

Figure 2: Vertical scale of ISSRs in meters with the proportional occurrence. Based on Dickson et al., 2009.

2.4. Converting these values to Flight Levels it can be observed that the impact on airspace capacity is significant (Fig. 3). Removing 5 Flight Levels from a portion of airspace will have significant implications on capacity and airspace efficiency.

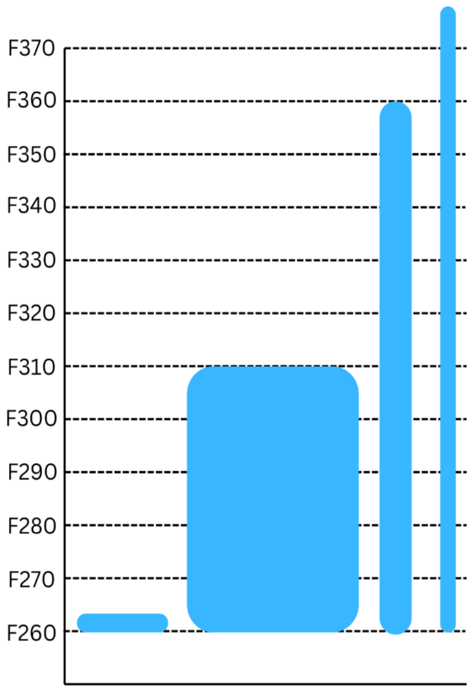

Figure 3: Table showing the vertical scale of ISSRs in terms of Flight Levels with proportional occurrence on the x-axis. Based on Dickson et al., 2009.

2.5. Reynolds (2009) shows that weather deviations resulted in a 10% reduction in efficiency, as well as reducing the airspace capacity. It can be expected that airspace inefficiency and a capacity reduction will likely be seen in the event of contrail navigational avoidance strategies coming into practice, as aircraft are instructed to deviate from ISSR. Sausen et al. (2023) acknowledge that the Maastricht Contrail Avoidance Trial had a negative impact on the ATCO workload and the airspace capacity.

2.6. Many of the discussions around contrail navigational avoidance are focused on the trade-offs of persistent contrail formation vs. additional CO_2 emissions of single flight missions and they fail to account for the entire system efficiency and capacity. As aircraft are instructed to deviate from a forecasted ISSR either laterally or horizontally this will have a knock-on effect with other airspace users. The efficiency of the entire system needs to be considered when developing the operational concept of contrail navigational avoidance strategies.

2.7. Shine and Lee (2021) have warned against implementing contrail navigational avoidance strategies until there is an improvement in the capabilities of ISSR forecasting. They argue that should contrail avoidance strategies be put in place with the current levels of uncertainty and lack of adequate ISSR forecasting capabilities we run the risk of unnecessarily emitting more CO_2, a portion of which will remain in the atmosphere for millennia. Over the short term, (less than 20 years) persistent contrails may have an appreciably larger radiative warming potential when compared to CO_2 emissions. However, when examining the medium to long-term (50-100 years) radiative warming potential of CO_2 is larger than persistent contrails (Lee et al., 2021). With the current capabilities there is a risk that aircraft are deviated from forecasted ISSR, but no contrails would have formed on the original route, or aircraft are deviated from forecasted ISSR, and contrails are still formed. Both scenarios result in the emission of extra CO_2, while one scenario has a double impact of increased CO_2 emissions and the net warming effect of persistent contrails (Shine and Lee, 2021; Sausen et al., 2023).

2.8. The current debate does not include the effects of contrail avoidance strategies on the ATM system as a whole and instead is focusing efforts on reducing the climate impact per flight. This is an unrealistic representation due to the ATM systems' many interdependencies. Changing the flight level of flights that are forecast to fly through potential ISSRs will have a knock-on effect for the system. The extra fuel burn could be experienced by many aircraft in a contrail avoidance portion of airspace, as the capacity of the airspace is reduced, the vertical efficiency will also be affected.

3. CONCLUSION

3.1. Many scientists agree that persistent contrails have a net warming effect.

3.2. Further data and research are required and encouraged to formulate a balanced approach to contrail avoidance strategies. There are several interdependent Key Performance Areas that need to be assessed including: safety, capacity, efficiency, environment and cost.

3.3. A balanced approach should be used to determine which of the global warming potential time frames are used. Choosing to pursue Contrail Avoidance Strategies may be favouring a short-term view and will essentially push the CO_2 impacts “down the road” for future generations to resolve.

3.4. The environmental impacts, considering the entire ATM system, needs to be assessed rather than on a per flight mission basis.

4. DRAFT RECOMMENDATIONS

4.1. New policy is added

IFATCA TPM (20XX), ATS X.XX – Contrail Avoidance Strategies
Proposal: Implementing trial contrail avoidance strategies shall: - Not be discouraged outright, in the interest of gathering relevant data - Report data in a transparent manner - Consider potential ATCO workload, and where necessary ATCO workload shall be managed to ensure safety - Determine a baseline of Airspace/Sector efficiency from which to compare operations under contrail avoidance strategies - Consider the efficacy of contrail avoidance strategies for the entire ATM system and not on single flight missions

5. REFERENCES

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