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POLICY REVIEW: TERRAIN AND OBSTACLE CLEARANCE

Presented by TOC

SUMMARY

This working paper analyses the current IFATCA policy regarding terrain and obstacle clearance in the context of work underway at the International Civil Aviation Organization and proposes amended IFATCA policies which are compatible with the objectives of the air traffic services.

1. INTRODUCTION

1.1. Achieving a safe vertical distance above terrain and obstacles is a critical component of a safe flight, as failure to achieve a safe vertical distance may result in controlled flight into terrain (CFIT). For flights conducted in accordance with the instrument flight rules (IFR), a safe vertical distance above terrain and obstacles is achieved by flying the aircraft at or above the established minimum level applicable to the aircraft's position and method of navigation.

1.2. During a review of IFATCA's radar monitoring policy, it became apparent to the Technical & Operations Committee (TOC) that there were issues which needed to be resolved with IFATCA's terrain and obstacle clearance policies. The issues present in the IFATCA policies are also present in the existing International Civil Aviation Organization (ICAO) provisions, where changes associated with the widespread use of vectoring and direct routing have introduced ambiguity regarding pilot and controller responsibilities.

1.3. Recent work by the ICAO Air Traffic Management Operations Panel (ATMOPSP) and the ICAO Flight Operations Panel (FLTOPSP) concerning cold temperature correction procedures has also addressed the issue of pilot and controller responsibilities for terrain and obstacle clearance. The work of the ATMOPSP and the FLTOPSP will be evaluated and progressed by the ICAO Air Navigation Commission in late 2024, so changes to the proposed procedures remain likely; nonetheless, the guiding principles of the work are appropriate for consideration in relation to the existing IFATCA policies.

2. DISCUSSION

2.1. Annex 11 — *Air Traffic Services* establishes the objectives of the air traffic services:

> The objectives of the air traffic services shall be to:
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> a) prevent collisions between aircraft;
> b) prevent collisions between aircraft on the manoeuvring area and obstructions on that area;
> c) expedite and maintain an orderly flow of air traffic;
> d) provide advice and information useful for the safe and efficient conduct of flights; and
> e) notify appropriate organizations regarding aircraft in need of search and rescue aid, and assist such organizations as required (ICAO, 2018, p. 2-2).

2.2. Of the objectives listed in Annex 11, the air traffic control service is intended to achieve objectives a), b) and c); the flight information service is intended to achieve objective d); and the alerting service is intended to achieve objective e). Other services with which controllers might be familiar – the air traffic flow management service and the airspace management service – are not components of the air traffic services and are instead components of air traffic management. The relationship of these various services are depicted in Figure 1.

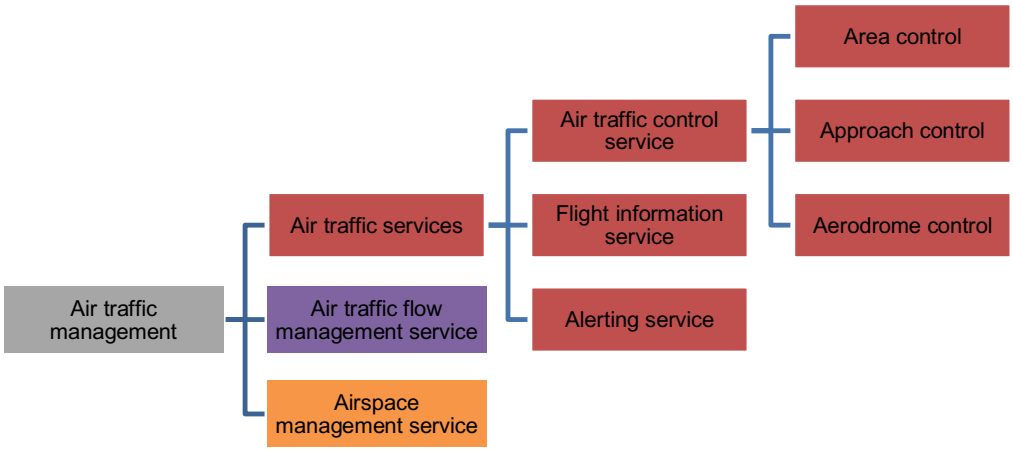

Figure 1. Air traffic management and its constituent services

2.3. It is notable that the five objectives of the air traffic services as established by Annex 11 do not include the prevention of collision between aircraft and terrain or obstacles (in this context terrain is the natural surface of the earth, and obstacles are man-made constructions extending up from the natural surface of the earth). Numerous notes in the ICAO provisions reiterate the fact that the prevention of collision with terrain and obstacles is not an objective of the air traffic services, e.g.:

> *Note 2.— The objectives of the air traffic control service as prescribed in Annex 11 do not include prevention of collision with terrain. The procedures prescribed in this document do not relieve pilots of their responsibility to ensure that any clearances issued by air traffic control units are safe in this respect* (ICAO, 2016, p. x).

2.4. With the introduction of radar and radar vectoring, it was recognised that pilots might not always be fully cognisant of the position of their aircraft when the controller was issuing headings which the pilot was not expecting. As a result, a procedure was introduced into the ICAO *Procedures for Air Navigation Services — Rules of the Air and Air Traffic Services* (PANS-RAC, Doc 4444) which applied during vectoring:

> 1.7.2 When vectoring an IFR flight, the radar controller shall ensure that adequate terrain clearance will exist at all times until the aircraft reaches the point where the pilot will resume his own navigation (ICAO, 1978, p. 10-6).

2.5. This vectoring procedure was updated in the 14th edition of what had since been re-named the ICAO *Procedures for Air Navigation Services — Air Traffic Management* (PANS-ATM, Doc 4444), with clarification that it was the 'prescribed obstacle clearance' which was to be maintained, not just 'adequate terrain clearance':

> 8.6.5.2 When vectoring an IFR flight, the radar controller shall issue clearances such that the prescribed obstacle clearance will exist at all times until the aircraft reaches the point where the pilot will resume own navigation.
>
> *Note 1.— When an IFR flight is being vectored, the pilot is often unable to determine the aircraft's exact position and consequently the altitude which provides the required obstacle clearance…* (ICAO, 2001, p. 8-8).

2.6. The introduction of the vectoring procedure to the ICAO provisions created a new responsibility for radar controllers. This responsibility contributed to ensuring that flights achieved a safe vertical distance above terrain and obstacles during radar vectoring. However, it is important to note that this additional controller responsibility did not change the objectives of the air traffic services, which continued to specifically exclude terrain and obstacle clearance.

2.7. In the ensuing years, with increasing use of direct routing, direct routing was included as a situation in which the additional controller responsibility also applied:

> 8.6.5.2 When vectoring an IFR flight and when giving an IFR flight a direct routing which takes the aircraft off an ATS route, the controller shall issue clearances such that the prescribed obstacle clearance will exist at all times until the aircraft reaches the point where the pilot will resume own navigation. When necessary, the relevant minimum vectoring altitude shall include a correction for low temperature effect.
>
> *Note 1.— When an IFR flight is being vectored, the pilot may be unable to determine the aircraft's exact position in respect to obstacles in this area and consequently the altitude which provides the required obstacle clearance…* (ICAO, 2007, p. 8-12).

2.8. Unfortunately, it was later found that the introduction of direct routing into the PANS-ATM paragraph 8.6.5.2 also introduced confusion regarding responsibilities and the application of the procedure. *Terrain and obstacle clearance* (WP/85) presented by TOC to the 2014 IFATCA Annual Conference spells out the various sources of confusion, including:

a) whether a controller was assuming responsibility for terrain and obstacle clearance, or merely assisting the pilot in carrying out their own responsibilities;
b) the inclusion of the direct routing procedure in the surveillance services section of the PANS-ATM;
c) the vagaries associated with direct routing, such as those which were pilot-initiated or controller-initiated, commencing from a known point or commencing immediately;
d) the use of direct routes in flight plans submitted by pilots/operators and direct routes mandated for inclusion in flight plans by ATC units; and
e) the exclusion of avoiding terrain and obstacles from the objectives of the air traffic service.

2.9. The TOC in 2014 was of the opinion that the issue necessitated clarification at the ICAO level, and introduced some IFATCA policy which will be analysed in this working paper.

2.10. A follow-up investigation was completed by TOC, and *Responsibility for terrain and obstacle clearance during weather avoidance* (WP/92) was presented to the 2015 IFATCA Annual Conference. This investigation specifically targeted the issue of pilot-initiated deviations off track and the mismatch between the ICAO procedure, which was predicated on a controller initiating direct tracking, and its potential application during controller approvals of pilot-initiated direct tracking. TOC in 2015 confirmed that the wording of the ICAO procedure was confusing, proposed action at the ICAO level to resolve the ambiguity, and developed additional IFATCA policy which will also be analysed in this working paper.

2.11. Minor editorial amendments were carried out on the relevant IFATCA policy following the 2022 IFATCA Annual Conference; however, no substantive changes were made to the policy.

2.12. The Cold Temperature Correction Working Group (CTC WG) is a joint working group of the ICAO ATMOPSP and the ICAO FLTOPSP. The CTC WG has been working to resolve another source of confusion in ICAO provisions – that of cold temperature corrections applied to during temperatures significantly colder than that predicted by the international standard atmosphere. During the conduct of its work, the CTC WG identified that cold temperature correction was inextricably linked to the broader issue of terrain and obstacle clearance. The CTC WG reached a conclusion similar to that reached by TOC – that the current ICAO provisions can be confusing for stakeholders. This is because the provisions are sometimes taken to infer that the responsibility for maintaining a safe vertical distance above terrain and obstacles transfers between the pilot-in-command and controllers.

2.13. The CTC WG undertook extensive work to resolve the confusion surrounding terrain and obstacle clearance responsibilities. The guiding principles of the CTC WG were that:

a) the State shall establish minimum flight altitudes;
b) the pilot shall correct those altitudes for the effects of temperature, pressure and wind, thereby calculating a pilot minimum safe altitude;
c) the ATC unit may, if it so chooses, make corrections to minimum flight altitudes in the same manner as pilots, except the ATC unit shall always make corrections to minimum vectoring altitudes for the effects of cold temperature;
d) the ATC unit shall provide the controller with the minimum levels which apply in their area of jurisdiction;
e) the controller shall, for IFR flights, always assign levels which are at or above the minimum level provided by the ATC unit;
f) the controller shall, for IFR flights being vectored, always issue clearances such that the aircraft is at or above the minimum vectoring altitude or other applicable minimum flight altitude;
g) the controller shall, for IFR flights cleared to proceed direct to a significant point at the completion of vectoring, issue clearances such that the aircraft is at or above the applicable minimum flight altitude until the aircraft reaches the significant point;
h) the pilot-in-command remains at all times responsible for the safety of the flight, which includes ensuring a safe vertical distance above terrain and obstacles; and
i) in controlled airspace the pilot-in-command compares the level assigned by the controller with the pilot's minimum safe altitude, and if the pilot-in-command is not satisfied that the level assigned by the controller ensures a safe vertical distance above terrain and obstacles, then the pilot-in-command is responsible for requesting an alternative ATC clearance.

2.14. There are three important aspects of these guiding principles to recognise. Firstly, the pilot-in-command is always responsible for ensuring a safe vertical distance above terrain and obstacles. This responsibility is never transferred to the controller even during vectoring or direct routing. Secondly, although the controller is never responsible for ensuring that a flight under their jurisdiction achieves a safe vertical distance above terrain and obstacles, the controller is responsible for always assigning levels which assist the pilot-in-command in carrying out the pilot-in-command's responsibilities for terrain and obstacle clearance. Finally, it must be understood that

under these guiding principles, additional controller responsibilities apply to aircraft being vectored and aircraft cleared to proceed direct to a significant point when at the completion of vectoring.

2.15. Before proceeding, it is important to clarify some aspects of altimetry, namely the various means by which an aircraft's vertical position is measured and described. An aircraft's vertical position is measured relative to a chosen datum – either:

a) the aerodrome reference point or the runway threshold;
b) the mean sea level (MSL); or,
c) the standard atmospheric pressure at MSL – 1 013.25 hPa.

2.16. An aircraft's vertical position is described differently depending on the datum which is chosen:

a) a vertical position measured above the aerodrome or runway threshold is a height;
b) a vertical position measured above MSL is an altitude; and,
c) a vertical position measured above the MSL standard atmospheric pressure of 1 013.25 hPa is a flight level.

2.17. Two related terms which should be understood are 'elevation', which is used to describe the vertical position of terrain and obstacles above MSL, and 'level', which is a generic term used to describe a height, an altitude and/or a flight level.

2.18. The various datums and means of expressing vertical position of aircraft, terrain and obstacles are illustrated in Figure 2.

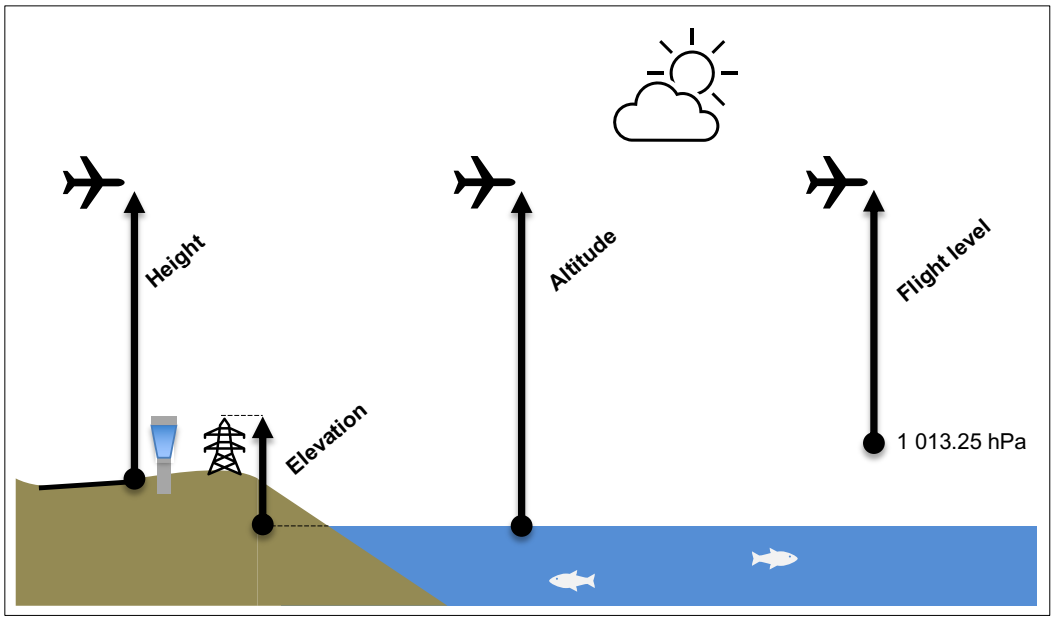

Figure 2. Height, altitude, flight level and elevation

2.19. While only one datum and means of expressing vertical position will be in use at any one time, it should be recognised that for any value of height, there is an equivalent value of altitude and flight level which will give the same vertical position. This equivalency becomes important when a conversion between means of expression is necessary. For example, the State will determine a minimum flight altitude, but aircraft vertical position might be described as a flight level. In this case, it is necessary for the ATC unit to ensure that the minimum flight level provided to controllers does not result if an aircraft vertical position which is lower than the applicable minimum flight altitude.

2.20. Having established the guiding principles of the current ICAO work regarding terrain and obstacle clearance as well as the nature of measuring and expressing aircraft vertical position (and recalling that the proposed procedures remain under development and are subject to change) the existing IFATCA policy regarding terrain and obstacle clearance may be analysed. It should be noted that the policies listed below appear in the IFATCA Technical and Professional Manual in two adjacent sections: *ATS 3.34 Terrain and Obstacle Clearance Responsibilities* and *ATS 3.35 Terrain and Obstacle Charting*.

Responsibility for terrain and obstruction clearance shall be clearly defined and shall always lie either with the crew or ATC. There shall never be a situation where doubt exists about who is responsible for this task.

ICAO documentation should provide clear and unambiguous language with regard to responsibility for terrain avoidance, including amendment to the Objectives of air traffic services to include the prevention of collisions between aircraft and terrain.

ATCOs should be provided with ATS surveillance tools and/or procedures to efficiently separate aircraft from terrain and obstacles (IFATCA, 2023, pp. 112-113).

2.21. It is evident that the current IFATCA policies regarding terrain and obstacle clearance are not in alignment with the guiding principles of the ICAO work being undertaken and should be reviewed. To ease the review, each segment of the policy will be reproduced and analysed individually.

2.22. **Responsibility for terrain and obstruction clearance shall be clearly defined and shall always lie either with the crew or ATC. There shall never be a situation where doubt exists about who is responsible for this task.**

This existing policy is somewhat contrary to the guiding principles of the ICAO work currently being undertaken, which recognises that maintaining a safe vertical distance above terrain and obstacles is not an objective of the air traffic services. Nonetheless, the desire for there to never be a situation where doubt exists about the allocation of responsibility is worthwhile. It is recommended that this policy is updated to reflect both the existing objectives of the air traffic services and the ongoing ICAO work, while retaining the desire for a clear allocation of responsibilities.

2.23. **ICAO documentation should provide clear and unambiguous language with regard to responsibility for terrain avoidance, including amendment to the Objectives of air traffic services to include the prevention of collisions between aircraft and terrain.**

ICAO is currently developing clear and unambiguous language regarding responsibility for terrain and obstacle avoidance; however, this work is not proposing to update the objectives of the air traffic services to include prevention of collision between aircraft and terrain and obstacles. Any changes arising from the work of the CTC WG will not be effective until November 2026 at the earliest, thus the work completed so far does not yet constitute satisfaction of the existing IFATCA policy. It is recommended to update this policy, deleting reference to the objectives of the air traffic services and instead emphasising the need for clear and unambiguous language regarding responsibility for terrain and obstacle clearance.

2.24. **ATCOs should be provided with ATS surveillance tools and/or procedures to efficiently separate aircraft from terrain and obstacles.**

This policy is somewhat contrary to the guiding principles of the ICAO work being undertaken, which is predicated on the fact that controllers will not ever assume responsibility for achieving a safe vertical distance above terrain and obstacles. For controllers to support the pilot-in-command, controllers must be equipped with information regarding the lowest level, i.e., the lowest height, altitude or flight level, which may be assigned to flights at each point in the controller's area of responsibility. It is recommended to redirect this policy towards the need for controllers to be provided with such information regardless of the availability of surveillance.

2.25. In addition to the policies discussed so far, there is also an IFATCA policy regarding the use of radar monitoring, minimum vectoring altitudes and terrain and obstacles, specified in the IFATCA Technical and Professional Manual in *ATS 3.8 Radar Monitoring*.

Radar monitoring should not be used as the means of providing separation with obstacles (terrain clearance) where aircraft are on their own navigation and below the Minimum Radar Vector Altitude (MRVA). Any escape procedure shall provide adequate terrain clearance from the point the aircraft is below the MRVA to the lowest defined altitude at which any such procedure can be initiated. States are required to assure this (IFATCA, 2023, p. 93).

2.26. This policy is contrary to the guiding principles of the ICAO work being undertaken, which does not envisage that a controller would provide separation between an aircraft and terrain and obstacles. While some States have implemented special procedures for low level operations regarding terrain and obstacles, the existence of these procedures do not change the guiding principles that the controller is never responsible for ensuring terrain and obstacle clearance. Instead, it is the responsibility to assign safe levels in accordance with the information provided by the ATC unit which is an ongoing controller responsibility. This controller responsibility applies regardless of whether radar monitoring is also provided.

3. CONCLUSION

3.1. Confusion surrounding the critical issue of responsibility for terrain and obstacle avoidance is a longstanding issue for civil aviation. IFATCA policies have attempted to provide a means for the industry of resolving the issues, including suggesting amending the objectives of the air traffic services.

3.2. Work currently underway at the ICAO to re-evaluate procedures for cold temperature corrections has similarly identified issues regarding responsibility for terrain and obstacle clearance. It was identified that cold temperature corrections are inextricably linked to terrain and obstacle clearance; therefore, efforts to resolve both issues simultaneously are ongoing within the ICAO ATMOPSP and FLTOPSP.

3.3. The guiding principles of the work underway at the ICAO are contrary to some existing IFATCA policies. Nonetheless, the guiding principles of the ICAO work are sound, and should lead to clarification and global consistency regarding this important issue. The guiding principles of the ICAO work should be supported by changes to existing IFATCA policy.

4. RECOMMENDATIONS

4.1. It is recommended that existing IFATCA policy:

Responsibility for terrain and obstruction clearance shall be clearly defined and shall always lie either with the crew or ATC. There shall never be a situation where doubt exists about who is responsible for this task.

is amended to read:

The pilot-in-command is always responsible for the safety of the flight, which includes maintaining a safe vertical distance above terrain and obstacles at all times. ATCOs are responsible to support the pilot-in-command by assigning levels which are not lower than the minimum levels provided by the ATC unit.

4.2. It is recommended that existing IFATCA policy:

ICAO documentation should provide clear and unambiguous language with regard to responsibility for terrain avoidance, including amendment to the Objectives of air traffic services to include the prevention of collisions between aircraft and terrain.

is amended to read:

ICAO provisions should provide clear and unambiguous language regarding the pilot-in-command responsibility for maintaining a safe vertical distance above terrain and obstacles.

4.3. It is recommended that existing IFATCA policy:

ATCOs should be provided with ATS surveillance tools and/or procedures to efficiently separate aircraft from terrain and obstacles.

is amended to read:

ATC units shall provide ATCOs with the minimum level(s) which may be assigned to IFR flights in their area of jurisdiction. Where any corrections for the effects of temperature, pressure and/or wind are necessary, such corrections shall be made by the ATC unit and the corrected level shall be provided to the ATCO.

4.4. It is recommended that existing IFATCA policy:

Radar monitoring should not be used as the means of providing separation with obstacles (terrain clearance) where aircraft are on their own navigation and below the Minimum Radar Vector Altitude (MRVA). Any escape procedure shall provide adequate terrain clearance from the point the aircraft is below the MRVA to the lowest defined altitude at which any such procedure can be initiated. States are required to assure this.

is deleted.

5. REFERENCES

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