

The Second UK State Consultation on a Harmonised Transition Altitude (TA): NVSM - Nominal Vertical Separation Minima Safety Report

CAP 1349 - 9

Downloaded from https://www.caa.co.uk/ on 04/17/2016 23:53:25 MDT



UK State TA Project Safety Report

on

Nominal Vertical Separation Minima

24 July 2015

NOMINAL VERTICAL SEPARATION MINIMA SAFETY REPORT

ISSUE

- 1 The implementation of a raised UK Transition Altitude generates challenges in the maintenance of an absolute 1 000ft separation at all times between interacting airport departures and arrivals operating on aerodrome QNH, and interactions with aircraft cruising on the Altimeter Setting Region QNH. It has been identified that the constrained application of a nominal Vertical Separation Minima¹ (VSM) would be of significant benefit.
- 2 The technical content of this paper was developed on a 'MOCOR 3'² basis within the joint project, and has been endorsed by the Transition Altitude (TA) Steering Group and independent specialists within the CAA's Safety and Airspace Regulation Group (SARG)³ and subsequently approved by the CAA's SARG. It presents an overview of progress, consolidates all evidences gained, and outstanding issues related to the delivery of nominal Vertical Separation Minima (VSM). This concept is a core element of the TA project and is a safety significant change that impacts on the CAA and Air Navigation Service Providers (ANSP) alike and for which detailed and careful analysis is required to ensure an acceptably safe implementation of a raised TA.

BACKGROUND

- 3 Work conducted in January 2014 by the joint Project highlighted the challenges posed by the maintenance of 1 000 ft standard vertical separation between:
 - a. Interacting multiple airport departure and arrival procedures, which require the specific airport QNH to be set, whilst for separation purposes treating the differing QNH as being one and the same within a given tolerance band; hence the term 'QNH tolerance'.
 - b. Interaction of aircraft cruising on the ASR QNH with aircraft operating on specific airport QNH whilst flying arrival and departure procedures.
- 4 As a result of this work, a proposal was made of a conceptual safety argument on the viability of utilising VSM of a nominal 1 000 ft within controlled air space (CAS), caused by the use of a QNH tolerance of up to 6 hPa between aircraft altimeter settings. An endorsement in principle for this concept of nominal VSM was provided by CAA SARG in March 2014 to enable further development work to take place. This endorsement was given, subject to the completion of additional works to:
 - a. Model aircraft Airborne Collision Avoidance System (ACAS) interactions to determine the effects of operating with a QNH tolerance band on ACAS event susceptibility and to demonstrate that there would be no increase in ACAS events attributable to this change.
 - b. Conduct validation simulation of the aircraft interactions that demonstrate that the concept of operations and associated procedures are acceptably safe.

¹ A nominal VSM exists when aircraft are assigned cruising altitudes separated by 1000ft but where the aircraft are operating with a variance of up to 5 hPa between their respective altimeter settings. In this way, less than 1000ft of air exists between the two aircraft and thus the separation is 'nominally' 1000ft, based on the assigned cruising altitude.

² MOCOR being the Maturity Of Cross Organisational Relationships; a framework that describes the maturity of the working relationship required between the UK CAA and the organisations that it regulates.

³ ISP Flight Ops Policy and Airspace/ATM Policy, AAA ATS Ops and Airspace Regulation, GA Unit and Flight Ops.

- c. Assess the availability to Air Traffic Service (ATS) providers of advanced information relating to larger variations in pressure (i.e. rapidly moving low pressure systems) in order to mitigate their impact.
 - d. Assess issues regarding the operation of aircraft with failed Mode S transponders.
 - e. Assess issues regarding access to CAS by military aircraft, including formations.
 - f. Determine the impact on ANSPs who currently have access to controlled airspace but do not operate on a NATS surveillance platform.
- 5 Subsequent work completed by the joint Project, endorsed by the TA Steering Group and presented within this paper has:
- a. collated and refined the evidence presented in January 2014;
 - b. addressed the requirements for further work placed identified by the CAA's SARG.
 - c. detailed the UK State TA Project's safety argument for the concept of a nominal VSM through the application of a QNH tolerance;
 - d. proposed the scope of the safety argument for the use of the nominal VSM concept and the generic contents of an ANSP safety case for its application.
 - e. proposed a maximum QNH tolerance value that may be applied by ANSPs; and,
 - f. proposed a number of applications of the nominal VSM principles.

SCOPE OF SAFETY ARGUMENT FOR THE USE OF NOMINAL VSM

- 6 Working under MOCOR principles, the project has and continues to take account of cross regulatory/industry roles and responsibilities in assessing and developing the safety argument for nominal VSM. However, the roles and responsibilities of the Regulator and ANSP must ultimately set the scope of the Regulatory Authority and ANSP's safety assurance requirements for the nominal VSM concept. In assessing the impact of the introduction of nominal VSM, generic safety issues (detailed at Annex A) were considered for further investigation and will be required to be addressed in the development of a nominal VSM safety argument; either by the Regulatory Authority or the ANSP.
- 7 The Regulatory Authority's role is to publish the VSM to be applied by ANSPs and to maintain oversight of that provision. Thus, the Authority must satisfy itself that those separation minima are, in principle, acceptably safe and that the effects on the ATM system are tolerable.
- 8 In accordance with normal safety assurance and oversight processes, it is the responsibility of the ANSP to demonstrate to the Regulatory Authority an acceptably safe means of delivering nominal VSM, through the application of a QNH tolerance. Thus, in order to gain approval from the Authority to provide nominal VSM, ANSPs will be required to satisfy the minimum requirements for a generic ANSP safety case identified by the joint Project; these being to:
- a. Demonstrate that safety, workload, or other factors necessitate the use of a QNH tolerance. This may be in the form of documented workload assessments or hazard analysis and should provide a rationale for the selection of a QNH Tolerance concept over alternative mitigations and a clear scope of use for the concept, including how the concept will be applied and will be time-bound in its application.

- b. Demonstrate that the concept will ensure safe and appropriate interactions with other ATC providers and for all airspace users.
- c. Address and mitigate the risks associated with the ATCO HF's which include but are not limited to the effects of:
 - (i) An increase in ACAS RA Events.
 - (ii) An increase in STCA Events.
 - (iii) The visual perception of nominal VSM on a surveillance display.
 - (iv) The increased workload associated with altimetry calculations.
- d. Explain fall-back procedures for use when ASRs are subject to significant weather fronts such that an out of tolerance gradient exists between the NASAS derived ASR QNH and the aerodrome QNH of surrounding aerodromes.
- e. Address, where applicable, the integration of formation flights with other traffic in a nominal VSM environment.
- f. Demonstrate how the ANSP's SMS will identify those incidents attributable to the use of a QNH tolerance.
- g. Where there is reliance on such equipment, address issues regarding the operation of aircraft with failed Mode S transponders.
- h. Where an ANSP determines that an exceptional requirement exists to utilise the maximum QNH tolerance value of 5 hPa, ANSPs should clearly articulate the justification for its use and the additional measures required to mitigate any consequent safety effects.
- (i) Where utilised, demonstrate how the 2 hPa altimeter setting variance associated with the use of the altimeter setting update procedure will be contained within the overall use of a QNH tolerance whose maximum value should not exceed 4 hPa and shall not exceed 5 hPa.

9 The MOD, as a MOCOR 3 partner, have been fully involved in the development of the nominal VSM concept and the UK State TA Project's safety argument. Where this paper refers to a Regulatory Authority and ANSPs, it is envisaged that this will apply equally to the MAA and CAA and to civil and military ANSPs. However, this is subject to agreement by the MAA and the satisfactory completion of safety assurance and oversight processes by the military ANSPs in accordance with MAA requirements.

SAFETY ARGUMENT

10 The UK State TA Project believes that the utilisation of a nominal VSM is acceptably safe, based on the application of an altimeter setting variance between 2 aircraft that should not exceed 4 hPa and shall not exceed 5 hPa.

CONSTRAINING CRITERIA AND ASSUMPTIONS

11 The following constraining criteria and assumptions apply to the application of nominal VSM:

- a. **Vertical Displacement per hPa.** Operationally, ATCOs and FISOs utilise a conservative, assumed, value of 30 ft per hPa to calculate aircraft separation. Calculations based on ISA values have determined that between the surface and

18 000 ft, 1 hPa equates to between 28.8 ft and 23.2 ft, dependent upon weather conditions. However, research has demonstrated that aircraft and ATM systems are programmed with an assumed value of 27.3 ft per hPa, irrespective of altitude; consequently, the separation values referred to hereafter will utilise the assumed value of 27.3 ft except where otherwise stated. That said, ATS personnel will continue to utilise the long accepted operational assumption of 30 ft per hPa in calculations. Table 1 below highlights the impact on VSM of utilising a QNH tolerance and the vertical difference between the absolute⁴ and nominal separations.

Altimeter Setting Variance (hPa)	Vertical Separation (ft) (27.3 ft per hPa)	Vertical Difference (absolute vs nominal) (ft)
1	973	27
2	945	55
3	918	82
4	891	109
5	864	136
6	836	164

Table 1: Effect of QNH Tolerance upon VSM.

- b. **Level Occupancy Criteria.** ICAO Doc 4444 Chapter 8 Para 8.5.5.2.1 states that 'The criterion which shall be used to determine that a specific level is occupied by an aircraft shall be ± 60 m (± 200 ft) in RVSM airspace. In other airspace, it shall be ± 90 m (± 300 ft), except that the appropriate ATS authority may specify a smaller criterion, but not less than ± 60 m (± 200 ft), if this is found to be more practical'. The mathematical underpinning for these figures is contained within ICAO Doc 9426 ATS Planning Manual and highlights that it is based upon both the correspondence error of SSR Mode C data and Assigned Altitude Deviation(AAD)⁵ of an aircraft. The UK stipulates that ± 200 ft will be used to assess level occupancy throughout its airspace⁶ and this paper has been developed on the basis that the UK would not adopt the alternative criterion specified by ICAO.
- c. **Rate of ACAS Events.** In order to determine a level of acceptability from which any impact of the use of 'nominal' VSM can be measured, it is reasonable to assume that the current incidence of ACAS events, both RA and TA, in UK airspace and thus the risks associated with them are considered to be Acceptable or Tolerable and As Low As Reasonably Practicable (ALARP) by both the Regulatory Authorities and operators.
- d. **Current Exposure to Risk from Nominal VSM Derived from Altimeter Setting Variance.** In the work conducted in January 2014, it identified that a form of nominal VSM is currently utilised within the London TMA to mitigate the effects of the atmospheric pressure gradient⁷ by 'deeming' certain aerodrome QNH values as being sufficiently similar to each other. Other than historic incident data or the lack thereof, we have limited means to prove, within a modern SMS construct, that current operations are acceptably safe. However, it is reasonable to argue that NATS, through their SMS, will have assessed that the risks associated with the current operation are

⁴ An absolute VSM is defined as the separation of 2 aircraft by 1 000 ft with both aircraft being operated on the same altimeter subscale setting, or, the separation of 2 aircraft by 1 000 ft, correcting for a variance in altimeter subscale settings using the operational assumption of 1 hPa equating to 30 ft.

⁵ AAD is the difference between the transponder Mode C altitude and the assigned altitude/flight level (ICAO Doc 9574).

⁶ MATS Part 1 Section 1 Chapter 6 Paragraph 10B.

⁷ A QNH Gradient refers to a stepped change in atmospheric pressure caused either by a weather front moving across an area, or by the difference in atmospheric pressure between a point at a distance from the pressure datum; for example the distance between EGSS and EGLL, the NASAS for the proposed London ASR.

at least tolerable and mitigated to ALARP. In turn, it is thus also reasonable to argue that the CAA, through their normal oversight activities, are content with the adequacy of NATS' current arrangements. However, the safety assurance from this legacy operation is not directly transferable to the significantly greater volume of airspace represented by a TA of 18 000ft.

- e. **Future Airspace Strategy.** FAS requires that all changes are justified on the grounds that they will directly reduce the risk, and/or contribute, to the development of a fundamentally safer system or at the very least maintain current levels of safety whilst delivering benefits in other areas.
- f. **Use Of VSM Within The ATM System.** A key task of the work conducted in January 2014 was to research the origins of the derivation of 1 000 ft VSM and its associated regulatory context; this is revisited at Annex B and includes additional material relating to aircraft formations within CAS.
- g. **MOD Operations Inside CAS.** The UK MOD has stated that their aircraft will operate wholly on the ASR QNH for the purposes of crossing CAS⁸ and as such will not utilise nominal VSM concepts in these circumstances, except for those procedures relating to the issuance of an updated altimeter setting – see paragraphs 25 to 27.
- h. **SID and STAR Profiles.** In determining the separation between interacting instrument flight procedure profiles from adjacent aerodromes (SID/SID, SID/STAR and SID/arrival transitions), the CAA ensures that the profiles accommodate potential along track and cross track errors. This assessment assumes that an aircraft follows the vertical profile of the SID; however, this is within the constraints imposed by the vertical errors that already exist within the ATM system and are accounted for within the nominal VSM concept.

EVIDENCE

- 12 Significant, progress has been made to further develop and refine the information presented in January 2014, which has highlighted the complexity of the errors already in existence within the ATM system prior to the addition of a QNH tolerance, how those errors relate to the VSM and the varying approaches by airframers toward aircraft automation. Moreover, further work has seen the development of the evidences required to create this Regulatory Authority level safety argument for nominal VSM and to satisfy the requirement for ACAS interaction modelling described at paragraph 4a. Whilst the endorsement in principle from CAA SARG included a requirement to test the nominal VSM concept through the conduct of ATM validation simulations⁹, due to the scope and maturity of the evidence presented herein, these simulations are no longer considered to be a pre-requisite for the CAA to approve the concept.

13 Operational Effects of Nominal VSM.

- a. **ATM System Vertical Error.** As originally articulated in January 2014, there are a number of sources of vertical error that exist within the current ATM system which are independent from the introduction of a raised TA and a nominal VSM concept. These vertical errors within the ATM System are composed of aircraft Total Vertical Error (TVE) and those that are introduced by surveillance systems in transmitting and processing altitude related data. The findings and evidence have been further developed and are consolidated at Annex C.

⁸ By which it is meant Airspace below FL 195, Airways, CTAs not associated with an aerodrome, for example Daventry, Clacton and Worthing CTAs, and TMAs.

⁹ described at paragraph 4b.

- b. **Effect of an Altimeter Setting Change on Aircraft Systems.** A raised TA increases the volume of airspace within which altitudes apply, and will thus increase the number of changes in altimeter setting required to be made by flight crews. However, research undertaken with aircraft operators and CAA SARG personnel has determined that the automated response by an aircraft to an altimeter setting instruction, i.e. whether it subsequently adjusts its vertical position to take account of the altimeter setting change, varies according to the automation ethos of the aircraft manufacturer (as shown at Annex D), the particular phase of flight (level flight, climbing/descending etc) and the automation mode utilised by the flight crew. This variation could create uncertainty as to whether aircraft will remain within the SSR verification and level occupancy criteria, which are the means of mitigating the accumulation of vertical errors within the current ATM system, and the key safety barrier in managing the addition of a QNH Tolerance. However, based upon evidence from CAA SARG Flight Operations personnel and through engagement with commercial aircraft operators¹⁰ it is clear that flight crews are aware of the risk of departing a cleared level due to changes in altimeter settings. Where aircraft are known **not** to automatically re-capture the cleared level following an altimeter setting change, flight crew procedures require the manipulation of the aircraft automation in order to ensure compliance with the ATC cleared level. In terms of the conceptual safety argument for nominal VSM, the surety that an automated aircraft will correct to its cleared level following an altimeter setting change means that a QNH Tolerance may be applied from a known datum altitude and thus the effect of that QNH Tolerance on the separation between aircraft can be accurately assessed.
- c. **Aircraft Formations.** SERA.3135 requires that for formation flights within controlled airspace, all aircraft within a formation shall be flown at 'a distance not exceeding... 30 m (100 ft) vertically from the flight leader'. As outlined in Annex B, the effect of SERA.3135 on the column of air that would exist around an aircraft formation is akin to the operation of an aircraft with an altimeter setting variance of 7.32 hPa (± 3.66 hPa); albeit that the elements of the formation would not be transponding and would thus have no impact on ACAS' onboard proximate aircraft. Given that SERA.3135 permits the operation of aircraft within CAS with as little as an 800 ft column of air between them, this figure should represent the extreme limit of the acceptable effect of a QNH tolerance on aircraft separation. Table 2 details the vertical separations derived from the interaction between aircraft formations and commercial air transport (CAT) flights and the use of an altimeter setting variance, before the effects of TVE are taken into account.

	Scenario			
	CAT vs Formation (Leader) ± 2 hPa	CAT vs Formation (Leader) ± 3 hPa	CAT vs Formation (Elements) ± 2 hPa	CAT vs Formation (Elements) ± 3 hPa
Vertical Separation	945 ft	918 ft	845 ft	818 ft

Table 2: Effect of SERA.3135 and QNH Tolerance upon VSM.

- d. **Airborne Collision Avoidance System (ACAS) Effects.**
- (i) Following a request from the HETA Rulemaking Group, Eurocontrol conducted an analysis of ACAS interactions in a nominal VSM environment, based upon a variance of up to 6 hPa between aircraft altimeter settings. The full results from this analysis are at Annex E with key findings below.

¹⁰ NATS Safety Partnership Agreement.

- (ii) ACAS' operate in accordance with a specific set of criteria that define the system's sensitivity levels and alarm thresholds. These thresholds vary according to the aircraft's altitude and are based upon the system measuring the 'time to go' to the closest point of approach between 2 aircraft, which should not infringe specific lateral and vertical criteria which vary with altitude. The Eurocontrol analysis utilised TCAS II, the sensitivity level definitions and alarm thresholds for which are at Annex F.
 - (iii) **ACAS RA.** Eurocontrol findings identified that no ACAS RA events would occur in level flight nominal VSM interactions utilising a QNH Tolerance of 6 hPa. Moreover, the Eurocontrol analysis identified minimum rates of climb/descent that would trigger an ACAS RA in nominal VSM interactions utilising a QNH tolerance of 6 hPa. However, it is acknowledged that ACAS RA occur in today's ATM system for climbing/descending interactions without the application of a nominal VSM; therefore, the challenge is in trying to quantify any potential increase in the rate of ACAS RA, as a direct result of utilising a nominal VSM.
 - (1) The level of detail contained within the CAA's MOR database relating to ACAS events was found to be insufficient to facilitate analysis. Consequently, it has not been possible to determine a baseline against which the Eurocontrol derived results can be compared.
 - (2) It can be stated that the use of a nominal VSM increases the likelihood of an ACAS RA event for climbing/descending interactions.
 - (3) Constraining the size of the QNH tolerance applied would have a direct influence on the likelihood of an ACAS RA.
 - (4) The likelihood of an ACAS RA occurring in climbing/descending aircraft interactions also relies on the lateral proximity and closure rate; therefore, it is not possible to quantify the increased likelihood of ACAS RA events.
 - (iv) **ACAS TA.** The Eurocontrol evidence proved that all level flight nominal VSM interactions above 5 000 ft within the lateral threshold criteria, utilising a QNH Tolerance of 6 hPa, would result in an ACAS TA event. A QNH tolerance value of 5 hPa would reduce the probability of occurrence; however, there is little leeway between the ACAS TA vertical alarm activation threshold of 850 ft and the nominal VSM of 863.5 ft. A QNH Tolerance value of 4 hPa or less would not result in an ACAS TA event in level flight.
 - (v) **ACAS Summary.** The results from the ACAS simulations highlight that the application of a QNH Tolerance may see an increase in ACAS RA events in climbing/descending scenarios between 10 000 ft and 20 000 ft, depending on the rate of climb applied in the final stage of closure and the magnitude of the QNH tolerance applied. In all other altitude bands and in level flight scenarios, the incidence of ACAS RA events is likely to remain similar to today's values. However, the critical result and, realistically, the result that has the most significant impact upon setting the magnitude of an acceptable QNH Tolerance, is that relating to ACAS TA events, due to the potential consequences of any increase in ACAS TA events on flight crews.
- e. **Effects of Nominal VSM Upon Flight Crews.** In order to determine the effects of nominal VSM, and specifically any increase in ACAS TA events, on flight crews, the opportunity was taken to present the concept to a meeting of the NATS Safety Partnership Agreement in November 2014. In response, CAT operators stated that a nominal VSM of 836 ft to 890 ft would not be visually perceptible from the cockpit; however, it would be apparent on cockpit ACAS displays. Indicated vertical

separations of 900 ft on ACAS displays were generally considered common; however, an indicated vertical separation of 800 ft was not considered to be common and would cause concern. Critically, the commercial operators did not consider a ACAS TA to be a common event and stated that it would cause concern on the flight deck; one operator reporting that they had mandated the reporting of ACAS TA events in order to identify geographic 'threat areas'. Operators also expressed concern about any possible increased incidence of ACAS TA events, specifically the risk of flight crew desensitisation to such events. Putting the FAS requirements on safety into context, on the basis of the evidence provided by the CAT operators, an increased risk of incidence of ACAS events should be considered to be unacceptable.

- f. **Meteorological Data.** Whilst not an element of the Regulatory Authority's safety argument to support the concept of nominal VSM through the application of a QNH tolerance, a range of meteorological data is required for consideration by the State and for use by ANSPs in developing their safety assurance and 'driving' the magnitude of a QNH tolerance in operational use.
- (i) **Intra-ASR QNH Gradient¹¹.** As stated earlier, given that through its normal oversight activities the CAA are content with the adequacy of the current arrangements within the London TMA, then by inference, they consider the variance between the disparate aerodrome QNH values within the London TMA to be acceptably safe for operations. Annex G provides a detailed comparison of the QNH of major aerodromes within the proposed ASRs to the QNH of the proposed ASR NASAS. Of specific interest is that it highlights that the QNH of all major aerodromes within the London TMA were within 2 hPa (ie ± 2 hPa) of the NASAS QNH on 99.22% of measured occasions between 1 Oct 06 to 30 Sep 11 and within 3 hPa (ie ± 3 hPa) on 99.99% of measured occasions during the same period. This data is supported by work conducted by NATS' Operational Analysis team who analysed pressure data from aerodrome METARs during the period July 2013 to October 2014, in order to assess the impact of the significant low pressure systems that affected the UK during the period. However, in terms of the application of a QNH tolerance operationally, the key information is the 'predictability' of atmospheric pressure changes, the accuracy of pressure forecasting by the Meteorological Office and the difference between NASAS derived ASR QNH and, thus, the gradient that would exist at ASR boundaries.
 - (ii) **Inter-ASR QNH Gradient.** Annex H is duplicated from the State CONOP document¹² and depicts the variance of pressure between NASAS. Met Office data demonstrates that the variance between NASAS derived ASR QNH values was greater than 3 hPa on between 8.9% and 58.8% of occasions¹³ during the measured period dependent upon location within the UK. This represents a significant variation across the UK and indicates the potential difficulty in applying a QNH tolerance concept at ASR boundaries.
 - (iii) **Predictability of Atmospheric Changes.** The UK Meteorological Authority has stated that "following a review of 9 locations in the UK (Ballykelly, Bridlington, Carlisle, Hurn, Kinloss, Langdon, Lerwick, St Mary's, and Stornoway), it was noted that the hourly atmospheric pressure change within ± 1 hPa occurs on 92-96% of occasions. Having reviewed the data and considered the location of the proposed NASAS, it is the view of the CAA that the hourly atmospheric pressure change within ± 1 hPa for locations within the UK FIRs would be 90-96 % of occasions"¹⁴. The CAA also recognises that a raised TA and the increased

¹¹ See footnote 7 on page 4 for a definition of a pressure gradient.

¹² CONOP V5.2 dated 2 November 2015.

¹³ Data from the Met Office's North Atlantic & Europe limited area forecast model were extracted from the archive for the 5-year study period from October 2006 to September 2011 inclusive. Met office reference document: 'Variation of pressure between neighbouring ASRs' dated 28th January 2014.

¹⁴ Email from UK Meteorological Authority to State TA Project Safety Manager on 5 June 2014.

volume of airspace in which QNH will apply generates pressure management issues for all ANSPs. Consequently, benefits have been identified in the introduction of a UK-wide standard procedure for managing aircraft altimeter settings following an update; paragraphs 23 to 25 herein refer.

- (iv) **Accuracy of Pressure Forecasting.** In support of ANSP activity and based upon 2 locations which the Meteorological Authority considered to be sufficiently representative of atmospheric conditions throughout the UK, forecasts for 1, 2 and 3 hours ahead were evaluated by the Meteorological Office and deemed by the Authority to be “extremely accurate...at this time range”¹⁵. 18 491 forecasts were reviewed at Charlwood (near Gatwick) and 17 945 were reviewed at Bishopton (near Glasgow) and the results from this analysis are in Table 3.

Charlwood	
Time	% of occasions where forecast QNH is within ± 1 hPa of actual QNH
T+1	99.95
T+2	99.88
T+3	99.69

Bishopton	
T+1	99.96
T+2	99.83
T+3	99.60

Table 3: Accuracy of Pressure Forecasting within the UK.

ANALYSIS OF NOMINAL VSM CONCEPT

- 14 Considered in combination with aircraft TVE, ICAO and EASA regulation relating to aircraft formation level keeping, and the relationship between feet and meters as units of measurement described by ICAO, it is clear that the concept of an absolute 1 000 ft of vertical separation between aircraft inside CAS is not sacrosanct. This view has been endorsed through informal coordination with ICAO’s Air Navigation Bureau (ANB), who have verbally confirmed that these factors are the basis for the use of the term ‘nominal’ in ICAO documentation. Consequently, it is reasonable to argue that no ‘legal’ impediment exists to the concept of a nominal VSM. Thus, the challenge is to demonstrate that the application of a nominal VSM through the use of a QNH tolerance does not have additional, unintended consequences within the ATM System; specifically, the effect of the application of a QNH tolerance on ACAS and whether the TVE within the ATM system can be contained within the existing level occupancy criteria when combined with a QNH tolerance. In the context of this paper, we need to demonstrate that the concept of nominal VSM is acceptably safe.
- 15 The results from the Eurocontrol ACAS simulations highlighted the potentially safety significant effect of the application of a QNH tolerance of 6 hPa on the incidence of ACAS TA events. Moreover, it is clear from the results of the Project’s engagement with CAT operators that an increase in ACAS TA events was considered to be unacceptable. Placing these into the context of the FAS directive on safety indicates that a tolerance of 6 hPa would be unacceptable. Setting the magnitude of an acceptable QNH Tolerance to below 6 hPa would move aircraft outside the vertical threshold activation minima for a ACAS TA event. In this way, the incidence of ACAS TA events would remain broadly similar to today’s operation

¹⁵ Email from UK Meteorological Authority to State TA Project Safety Manager on 20 May 2014.