STATEMENT of COMPLIANCE

with

TSO-C87

For the AHV1600
Low Range Radio Altimeter

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1. SCOPE

1.1 GENERALITY

This document permits TCF to state the compliance status of the Radio Altimeter AHV1600 P/N AHV1600-01-01 00 A to each requirements of the TSO C87.

A compliance matrix is given in paragraph 4 and is providing the list of documentary evidences related to every TSO-C87 requirement and the performance declaration.

1.2 ABBREVIATION AND ACRONYMS

ADTP	:	Acceptance and Design Test Procedure
ADTR	:	Acceptance and Design Test Report
BIT	:	Built In Test
CDC_LAR	:	Cahier Des Charges des Lignes A Retard
EQTP	:	Environmental Qualification Test Procedure
EQTR	:	Environmental Qualification Test Report
ES	:	Equipment Specification
EUROCAE	:	European Organization for Civil Aviation Equipments
FTA		Fault tree analysis
GM_LAR	:	Guide de Maintenance des Lignes A Retard
ICAO	:	International Civil Aviation Organization
ICD	:	Interface Control Document
ITU	:	International Telecommunications Union
MPS	:	Minimum Performance Standard
N-A	:	Not Applicable
PVM_LAR	:	Procès Verbal de Maintenance des Lignes A Retard
RF	:	Radio Frequency
r.m.s (rms)	:	Root Mean Square
RPR	:	Reliability Prediction Report

RTCA	:	Radio Technical Commission of Aeronautics
TCF	:	THALES Communications France
TSO	:	Technical Standard Order
WG	:	Working Group

2. APPLICABLE DOCUMENTS

Document Identifier	***Document Title***
[1] TSO-C87 dated January 1966	Minimum performance specification for airborne low range radio (radar) altimeter equipment
[2] RTCA DO160E	Environmental Conditions and Test Procedures for Airborne Equipment
[3] ITU radio regulations edition 2004	International Telecommunication Union: - RR5: table of frequency allocation. - AP3 (Rev. WRC-03): table of maximum permitted power levels for spurious or spurious domain emissions.
[4]	
[5]	
[6]	
[7]	
[8]	
[9]	

3. REFERENCED DOCUMENTS

Document Identifier	*Document Title*
[10] ES n°61 814 657 - 306 issue -B dated 13/05/2009	Equipment Specification
[11] ICD n° 61 814 659 - 558 issue -B dated 31/03/2009	Interface Control Document
[12] ATR n° 62 101 820 – 088 issue -A dated 17/06/09	Acceptance Test Report
[13] DDP n°62 390 481 – 580 issue -A dated 01/07/09	Declaration of Design and Performance
[14] OIM n°36719226-AA revision 0 dated 01/07/09	Operation and Installation Manual
[15] ADTP n° 61 816 442 - 090 issue -A dated 15/04/2009	Acceptance and Design Test Procedure
[16] ADTR n° 61 816 443 - 088 issue -B dated 12/05/2009	Acceptance and Design Test Report of the AHV1600 Transceiver prototype SN0015
[17]	
[18]	
[19] CADTR n° 62 134 087 - 279 issue -- dated 13/03/2008	Complementary Acceptance and Design Test Report of the unwanted RF emission
[20] Label marking data 62 135 645 – 080 issue -- dated 11/06/09	Label Marking Data
[21]	
[22]	
[23]	
[24]	
[25] Matrix DO160E n° 62 444 008 - 570 issue -- dated 30/06/09	Statement of compliance with DO160E

4. COMPLIANCE MATRIX WITH TSO-C87

TSO-C87 requirement		***Compliance OK / NOK / N-A***	***Documentary evidences or comments***
Ref. §	***Content***		
(a)	*Applicability*		
	This Technical Standard Order prescribes the minimum performance standards which airborne low-range radio altimeter equipment must meet in order to be identified with the applicable TSO marking. New models of the equipment which are to be so identified and which are manufactured on or after the effective date of this section must meet the Minimum Performance Standards For Air-borne Low-Range Radio Altimeters set forth at the end of this section.	**N-A**	
(b)	*Markings*		

TSO-C87 requirement		Compliance OK / NOK / N-A	Documentary evidences or comments
Ref. §	**Content**		
(1)	In addition to the markings required by § 37.7, the equipment <u>must</u> be marked to indicate the environmental extremes over which it has been designed to operate. There are six environmental procedures outlined in the "Environmental Test Procedures for Airborne Electronic Equipment" which have categories established. These <u>must</u> be identified on the nameplate by the words "Env. Cat." followed by six letters which identify the categories designated in the document. Reading from left to right, the category designations must appear on the nameplate in the following order so that they may be readily identified — (i) Temperature-altitude category; (ii) Vibration category; (iii) Audio-frequency magnetic field susceptibility category; (iv) Radio-frequency susceptibility category; (v) Emission of spurious radio-frequency energy category; and (vi) Explosion category.	**NOK**	TCF declares that the AHV1600 Transceiver is in compliance with the marking requirements issued by the Civil Aviation. DO160E Env. Cat. [(B4)X]BBB[RG]XWFDFSZZAZ[ZC][HF]M[(A4G33)(A3J33)]XXAX *A label description document is provided [20]*
(2)	A typical nameplate identification might be as follows: Env. Cat. DBAAAX.	**NOK**	TCF declares that the AHV1600 Transceiver is in compliance with the marking requirements issued by the Civil Aviation. DO160E Env. Cat. [(B4)X]BBB[RG]XWFDFSZZAZ[ZC][HF]M[(A4G33)(A3J33)]XXAX *A label description document is provided [20]*

TSO-C87 requirement		**Compliance OK / NOK / N-A**	***Documentary evidences or comments***
Ref. §	***Content***		
(3)	If a manufacturer desires to substantiate his equipment under two categories, he must mark the name-plate with both categories in the space designated for that category by placing one letter above the other in the following manner: Env. Cat. ABAAAX D	**NOK**	Environmental categories are detailed into the DDP. It would be unpractical to mark these categories on the label. Declaration of Design and Performance [13]
(c)	*Data requirement* In accordance with §37.5, the manufacturer <u>must</u> furnish to the Chief, Engineering and Manufacturing Branch, Flight Standards Division, Federal Aviation Agency, in the region in which the manufacturer is located, the following technical data:	**OK**	
(1)	Manufacturer's operating instructions and equipment limitations.	**OK**	Declaration of Design and Performance is provided [13]
(2)	Installation procedures with applicable schematic drawings, wiring diagrams, and specifications. Any limitations, restrictions, or other conditions pertinent to installation must be indicated.	**OK**	Operation and Installation Manual is provided [14]
(3)	One copy of the manufacturer's test report.	**OK**	Acceptance Test Report is provided [12]
(d)	*Previously approved equipment.* Airborne low-range radio altimeter models approved prior to the effective date of this section may continue to be manufactured under the provisions of their original approval.	**N-A**	
1.0	*General Standards.*		

TSO-C87 requirement		*Compliance OK / NOK / N-A*	*Documentary evidences or comments*
Ref. §	*Content*		
1.1	*Rating of Components.* The equipment shall not incorporate any component of such rating that, when the equipment is operated throughout the range of the specified environmental tests, the rating established by the manufacturer of the component is exceeded. For electron tubes and transistors, either the tube or manufacturer's continuous commercial service rating, his established pulse rating, or his approved rating as applied to the particular application, whichever is appropriate, shall apply, except for the heaters and filaments. The voltage applied to the heaters and filaments of electron tubes shall be within 5 percent of the manufacturer's rating, or at a value approved by the tube manufacturer for the particular service, when the equipment is operated under standard operating conditions. When the heaters and filaments are connected in series, the 5 percent tolerance shall apply to the sum of their voltage ratings.	**OK**	TCF declares that the components, the materials and the processes used to make the AHV1600 Transceiver are in compliance with the regulations issued by the Civil Aviation.
1.2	*Operation of Controls.* The operation of controls intended for use during flight, at all possible position combinations and sequences, shall not result in a condition whose presence or continuation would be detrimental to the continued performance of the equipment.	**OK**	TCF declares that the operation of controls intended for use during flight, at all possible position combinations and sequences, do not result in a condition whose presence or continuation would be detrimental to the continued performance of the equipment.
1.3	*Accessibility of Controls.* Controls which are not normally adjusted in flight shall not be readily accessible to flight personnel.	**OK**	TCF declares that Controls which are not normally adjusted in flight are not readily accessible to flight personnel. See ICD document [11]
1.4	*Effects of Tests.* Unless otherwise stated, the application of the specified tests shall produce no subsequently discernible conditions which would be detrimental to the continued performance of the equipment.	**OK**	TCF declares that the application of the specified tests do produce no subsequently discernible conditions which would be detrimental to the continued performance of the equipment.

TSO-C87 requirement		Compliance OK / NOK / N-A	Documentary evidences or comments
Ref. §	**Content**		
2.0	*Minimum Performance Standards Under Standard Conditions* The test procedures applicable to the determination of the performance of air-borne low-range radio altimeter equipment under standard conditions are set forth in Appendix A of this standard. Test procedures which provide equivalent information may be used. Compliance with the performance requirements may be shown by an appropriate combination or data obtained from the laboratory and/or flight measurements. Calculations and extrapolations employing the basic test data may be used to make a direct determination of equipment performance by means of these basic test procedures.	**N-A**	

TSO-C87 requirement		**Compliance OK / NOK / N-A**	**Documentary evidences or comments**
Ref. §	***Content***		
2.1	*Accuracy of Pilot's Display.* The altitude information displayed for the pilot's use <u>shall</u> not exhibit errors in excess of those set forth in Column 1 of Table I for 95 percent of all observations conducted under any combination of the measurement conditions listed with the table. NOTE: The above measurement conditions need not be applied simultaneously by may be combined by analytical methods. Measurement Conditions: (1) Lateral velocities from 0 to 50 feet per second. (2) Longitudinal velocities from 0 to 300 feet per second. (3) Pitch angel range of 0 to ±15 degrees. (4) Roll angel range of 0 to ±20 degree (5) Vertical velocity from 0 to 15 feet per second up to 100 feet and 0-20 feet per second above 100 feet.	**N-A**	TCF is not responsible for pilot's display

TABLE I. - ACCURACY REQUIREMENTS AND MEASUREMENT CONDITIONS

Altitude (ft)*	*Vertical velocity (ft./sec.)*	*Column 1- Pilot's display*	*Column 2- Precision equipment output (ft.)*
3 to 100	0 to 15	±5 ft.	±3 ft
100 to 500	0 to 20	±5 %	±3 %
500 to that altitude for which the equip-ment is designed	0 to 20	±7 %	±5 %

*That "one-way" distance measured form the antenna to the terrain. The altitude may be offset by a distance equal to the vertical distance between the antennas and the terrain at touchdown.

TSO-C87 requirement		Compliance OK / NOK / N-A	Documentary evidences or comments
Ref. §	**Content**		
	NOTE: Conditions 1 though 5 above include all associated Doppler shift and step errors. Further, the equipment shall continue to function and provide altitude information which exhibits no errors in excess of ±20 percent of the indicated altitude for 95 percent of all observations at bank angles from 20 to 30 degrees.		
2.2	*Accuracy of the Precision Equipment Output.* The equipment need not provide as a condition of compliance with this minimum performance standard a precision equipment output for use in conjunction with autopilots, flight directors, or similar flight control computing devices. However, the altitude data supplied by such outputs, where provided, shall not exhibit errors in excess of those set forth in Column 2 of Table I for 95 percent of all observations conducted under any combination of the measurement conditions listed in 2.1.	**OK**	*See Annex A* "Altitude Accuracy and loop gain"
2.3	*Precision Equipment Output Noise.* The r.m.s. noise content of the data provided by the precision equipment output shall be less than 0.25 foot at all altitudes up to 100 feet.	**OK**	*See Annex A* "Altitude noise"
2.4	*Time constant.* When the equipment is abruptly subjected to an altitude change of not more than 10 percent of the indicated altitude or 20 feet whichever is smaller the transfer function time constant of the precision equipment output shall not exceed 0.1 second. Further, for transients of 20 feet or less at altitudes of 200 feet or less the system shall not lose lock. If the equipment should lose lock due to loss of signal at altitudes above 200 feet and up to the maximum altitude for which it is designed, it shall recapture the signal in less than one second.	**OK**	*See Annex A* "Time constant"

TSO-C87 requirement		***Compliance*** ***OK / NOK / N-A***	***Documentary evidences or comments***
Ref. §	***Content***		
2.5	*Rate Data.* The equipment need not provide a rate data output as a conditions of compliance with this minimum performance standard. However, those altimeters which do have rate outputs shall comply with the following requirements regarding range and accuracy for at least 95 percent of all observations for heights form the terrain to the antenna in the range from : RATE DATA *Altitude (ft.)* — *Range (ft./sec.)* — *Accuracy (ft./sec.)* 3-100 — 0-15 — ±(1.5ft.+0.01h+0.1/r/) 100-200 — 0-20 — ±(2.0ft.+0.01h+0.1/r/) Where: h = altitude in feet. /r/ = absolute value of rate (feet/sec.).	**N-A**	Rate data output not provided.
2.6	*Failure Warning System.*		
(a)	*Warning conditions.* A failure warning system shall be incorporated in the equipment to indicate to the pilot, and to any systems which may be utilizing the altimeter data, the existence of the following conditions: (1) Loss of power. (2) Loss of signal or altitude sensing capability when within the manufacturer's stated operating altitude range.	**OK**	(1) Loss of power is monitored by the BIT (Built in test). In case of loss of power the SSM of all label is set to NCD. *See ICD Document [11]* *(2)* In case of loss of signal the SSM of the height label is set to NCD (Non Computed Data) *See ES Document [10]*

TSO-C87 requirement		Compliance OK / NOK / N-A	Documentary evidences or comments
Ref. §	**Content**		
(b)	*Warning indication characteristics.* An indication plainly discernible under all normal flight conditions shall be provided. If a flag is used, it shall be as large as practicable commensurate with the display.	**N-A**	TCF is not responsible for pilot's display
2.7	*Self Test Feature.* If a self test-feature is provided, any probable malfunction of the self-test feature shall not degrade the performance of the radio altimeter.	**OK**	TCF declares that any probable malfunction of self test feature will not degrade the performance of the radio altimeter. *ICD Document [11]* *ES Document [10]*
2.8	*Transmitting Operating Frequency.* The transmitter shall be operated within a frequency band available for the operation of airborne radio altimeters in the Aeronautical Radio Navigation Service and in accordance with applicable Federal Aviation Agency and Federal Communications Commission Rules and Regulations.	**OK**	TCF declares that the AHV1600 Transceiver uses the radio frequency bandwidth from 4.2GHz up to 4.4GHz with a spurious radiation characteristics lower than -40dBc. These characteristics are exclusively measured at TX terminal of the Radio Altimeter unit (i.e. not at TX antenna terminal with its transmission line). *ICD document [11] §3.2.3.2.* *ITU document [3].* *CADTR document [19]*
2.9	*Maximum Altitude Range.* To satisfactorily perform its intended function, the maximum range shall be at least 500 feet.		TCF declares that the equipment is intended to perform satisfactorily his function for altitude range from 0 to 5000ft *ES Document [10]*
3.0	*Minimum Performance Standards Under Environmental Conditions.* Unless otherwise specified, the test procedures applicable to a determination of performance of radio altimeter equipment under environmental conditions are set forth in the FAA Document for "Environmental Test Procedures for Airborne Electronic Equipment", dated August 31,1962.	**N-A**	Compliant to DO160E . *STATEMENT of COMPLIANCE with D160E document [25]*
3.1	*Temperature-Altitude.*		

TSO-C87 requirement		Compliance OK / NOK / N-A	Documentary evidences or comments
Ref. §	***Content***		
(a)	Low Temperature - When subjected to this test: (1) The requirements of paragraphs 2.3 and 2.6 shall be met. (2) The requirements of paragraphs 2.1 and 2.2 shall be met using the procedure set forth in 2.2 of Appendix A. (3) All mechanical de-vices shall perform their intended functions.	**NOK**	Compliant to DO160E . *STATEMENT of COMPLIANCE with D160E document [25]*
(b)	High Temperature - (1) When the equipment is operated at the High Short-Time Operating Temperature: (a) The requirements of paragraphs 2.1 and 2.2 shall not be degraded by more than a factor of 2 from the values set forth using the procedures set forth in 2.2 and 2.3 respectively, of Appendix A. (b) The requirements of paragraph 2.6 shall be met. (c) All mechanical de-vices shall operate satisfactorily. (2) When the equipment is operated at the High Operating Temperature: (a) The requirements of paragraphs 2.3 and 2.6 shall be met. (b) The requirements of paragraphs 2.1 and 2.2 shall be met using the procedures set forth in 2.2 of Appendix A.	**NOK**	Compliant to DO160E . *STATEMENT of COMPLIANCE with D160E document [25]*
(c)	Decompression (Applicable only to Category D equipment of temperature-Altitude Test) - When the equipment is subjected to this test: (1) The requirements of paragraphs 2.1 and 2.3 shall be met using the procedures set forth in 2.2 and 2.3, respectively, of Appendix A. (2) All mechanical devices shall perform their in-tended functions.	**NOK**	Compliant to DO160E . *STATEMENT of COMPLIANCE with D160E document [25]*

TSO-C87 requirement		Compliance OK / NOK / N-A	Documentary evidences or comments
Ref. §	**Content**		
(d)	Altitude-When the equipment is subjected to this test: (1) The requirements of paragraphs 2.3 and 2.6 shall be met. (2) The requirements of paragraphs 2.1 and 2.2 shall be met using the procedures set forth in 2.2 of Appendix A.	**NOK**	
3.2	*Humidity.* After subjection to this test and: (a) Within 15 minutes from the time that primary power is applied: (1) The requirements of paragraph 2.6 shall be met. (2) All mechanical devices shall operate satisfactorily. (b) Within 4 hours from the time that primary power is applied: (1) The requirements of paragraphs 2.3 and 2.6 shall be met. (2) The requirements of paragraphs 2.1 and 2.2 shall be met using the procedures set forth in 2.2 of Appendix A. (a) Following the application of the Operational Shocks. (1) The requirements of paragraphs 2.3 and 2.6 shall be met. (2) The requirements of paragraphs 2.1 and 2.2 shall be met using the procedures set forth in 2.2 of Appendix A. (b) Following the application of the Operational Shocks, the equipment shall have remained in its mounting and no part of the equipment or its mounting shall have become detached and free of the shock test table or the equipment under test.	**NOK**	Compliant to DO160E . *STATEMENT of COMPLIANCE with D160E document [25]*
3.4	*Vibration.* When subjected to this test: (1) The requirements of paragraphs 2.3 and 2.6 shall be met. (2) The requirements of paragraphs 2.1 and 2.2 shall be met using the procedures set forth in 2.2 of Appendix A.	**NOK**	Compliant to DO160E . *STATEMENT of COMPLIANCE with D160E document [25]*

TSO-C87 requirement		Compliance OK / NOK / N-A	Documentary evidences or comments
Ref. §	***Content***		
3.5	*Temperature Variation.* When subjected to this test: (a) The requirements of paragraphs 2.3 and 2.6 shall be met. (b) All mechanical de-vices shall perform their in-tended functions.	**NOK**	Compliant to DO160E . *STATEMENT of COMPLIANCE with D160E document [25]*
3.6	*Power Input Variation.* When subjected to this test: (1) The requirements of paragraphs 2.3 and 2.6 shall be met. (2) All mechanical de-vices shall perform their in-tended functions.	**NOK**	Compliant to DO160E . *STATEMENT of COMPLIANCE with D160E document [25]*
3.7	*Low Voltage.* (a) When the equipment is subjected to the first part of the low voltage test procedure set forth in 9.2a, of Environmental Test Procedures for Airborne Electronic Equipment document. (1) The equipment shall operate electrically and mechanically. (2) The requirements of paragraph 2.6 shall be met. (b) When the equipment is subjected to the second part of the low voltage test procedure set forth in 9.2b(1), of Environmental test Procedures for Airborne Electronic Equipment document. (1) The requirements of paragraphs 2.3 and 2.6 shall be met. (2) The requirements of paragraphs 2.1 and 2.2 shall be met using the procedures set forth in 2.2 of Appendix A. (c) When the equipment is subjected to the third part of the low voltage test procedure set forth in 9.2b(2), of Environmental Test Procedures for Airborne Electronic Equipment documents, there shall be no evidence external to the equipment of the presence of fire or smoke.	**NOK**	Compliant to DO160E . *STATEMENT of COMPLIANCE with D160E document [25]*

TSO-C87 requirement		Compliance OK / NOK / N-A	Documentary evidences or comments
Ref. §	**Content**		
3.8	*Conducted Voltage Transient.* (a) Subsequent to the subjection of the intermittent transient test, the requirements of paragraphs 2.1 and 2.3 shall be met using the procedures set forth in 2.2 of Appendix A. (b) When being subjected to the repetitive transient test the requirements of paragraphs 2.3 and 2.6 shall be met.	**NOK**	Compliant to DO160E . *STATEMENT of COMPLIANCE with D160E document [25]*
3.9	*Conducted Audio-Frequency Susceptibility.* When subjected to this test: (a) The requirements of paragraphs 2.3 and 2.6 shall be met. (b) The requirements of paragraphs 2.1 and 2.2 shall be met using the procedures set forth in 2.2 of Appendix A.	**NOK**	Compliant to DO160E . *STATEMENT of COMPLIANCE with D160E document [25]*
3.10	*Audio-Frequency Magnetic Field Susceptibility.* When subjected to this test: (a) The requirements of paragraphs 2.3 and 2.6 shall be met. (b) The requirements of paragraphs 2.1 and 2.2 shall be met using the procedures set forth in 2.2 of Appendix A.	**NOK**	Compliant to DO160E . *STATEMENT of COMPLIANCE with D160E document [25]*
3.11	*Radio-Frequency Susceptibility (Radiated and Conducted).* When subjected to this test: (a) The requirements of paragraphs 2.3 and 2.6 shall be met. (b) The requirements of paragraphs 2.1 and 2.2 shall be met using the procedures set forth in 2.2 of Appendix A.	**NOK**	Compliant to DO160E . *STATEMENT of COMPLIANCE with D160E document [25]*
3.12	*Explosion (When Required).* During the application of this test the equipment shall not cause detonation of the explosive mixture within the test chamber.	**N-A**	

TSO-C87 requirement		Compliance OK / NOK / N-A	Documentary evidences or comments
Ref. §	***Content***		
3.13	*Emission of Radio-Frequency Energy.* The levels of conducted and radiated spuriou7s radio-frequency energy emitted by the equipment shall not exceed those levels specified in Appendix A to the Federal Aviation Agency document, "Environmental Test Procedures for Airborne Electronic Equipment", dated August 31, 1962 for the air-craft category for which the equipment is designed.	**NOK**	Compliant to DO160E . *STATEMENT of COMPLIANCE with D160E document [25]*

Appendix A

Altitude Accuracy and loop gain

1. LABORATORY TEST

1.1 LABORATORY TEST DEVICE

1.1.1 STANDARD LABORATORY TEST EQUIPMENT

Name	***Manufacturer name***	***Type***	Serial number	Validity expiration
ARINC429 transmitter / receiver	JCAIR	429E	393606	None
DC Power supply	TTI	EL302D	TH102492	-

1.1.2 SPECIAL LABORATORY TEST EQUIPMENT

Name	***Part number***	***Serial number***	***Validity expiration***
“Banc système”	62 057 140 AA	00001	-
“Banc Hyperfréquence”	61 488 676 AA	SN102	30/2009

1.2 PROCEDURE

For height accuracy measurement, the RF attenuation between the TX and RX connector of the AU Transceiver is the attenuation corresponding to σ0 = -20dB (lower part of the sensitivity curve for the considered height) and which has to be calculated from sensitivity curve.

RF attenuation for height accuracy is obtained by progressive decrease of attenuation on the delay line test bench until reach the value. Then the measure of height accuracy may be noted.

Height measurement accuracy above all type of terrain :

- Set the *“Banc Hyperfréquence”* on the following test configuration
  - AID simulated height
  - RF attenuation simulated : σ0 = -20dB (AU Transceiver in Track function)

Read the exact value of the AID simulated height according to the last revision of the *“Banc Hyperfréquence”*

(1) Record the theoretical height at AID simulated

H_{true} at AID

On the *“IHM ARINC429”*, check the height accuracy

(2) Measure the height accuracy at AID simulated for σ0 = -20dB
H_{true} ± (3ft)

On the *“IHM ARINC429”*, check the statistical repartition of the observations

(3) Measure the statistical repartition of the observations at AID simulated
≥ 95%

- Set the *“Banc Hyperfréquence”* on the following test configuration
  - RF attenuation simulated : σ0 = 0dB (AU Transceiver in Track function)

On the *“IHM ARINC429”*, check the height accuracy

(4) Measure the height accuracy at AID simulated for σ0 = 0dB
H_{true} ± (3ft)

- Set the *“Banc Hyperfréquence”* on the following test configuration
  - 100ft simulated height
  - RF attenuation simulated : σ0 = -20dB (AU Transceiver in Track function)

Read the exact value of the 100ft simulated height according to the last revision of the *“Banc Hyperfréquence”*

(5) Record the theoretical height at 100ft simulated
H_{true} at 100ft

On the *“IHM ARINC429”*, check the height accuracy

(6) Measure the height accuracy at 100ft simulated for σ0 = -20dB
H_{true} ± (3ft)

On the *“IHM ARINC429”*, check the statistical repartition of the observations

(7) Measure the statistical repartition of the observations at 100ft simulated
≥ 95%

- Set the *“Banc Hyperfréquence”* on the following test configuration
  - RF attenuation simulated : σ0 = 0 dB (AU Transceiver in Track function)

On the *“IHM ARINC429”*, check the height accuracy

(8) Measure the height accuracy at 100ft simulated for σ0 = 0dB
H_{true} ± (3ft)

- Set the *“Banc Hyperfréquence”* on the following test configuration
  - 250ft simulated height
  - RF attenuation simulated : σ0 = -20dB (AU Transceiver in Track function)

Read the exact value of the 250ft simulated height according to the last revision of the *“Banc Hyperfréquence”*

(9) Record the theoretical height at 250ft simulated
H_{true} at 250ft

On the *“IHM ARINC429”*, check the height accuracy

(10) Measure the height accuracy at 250ft simulated for σ0 = -20dB
H_{true} ± (7,5ft)

On the *“IHM ARINC429”*, check the statistical repartition of the observations

(11) Measure the statistical repartition of the observations at 250ft simulated
≥ 95%

- Set the *“Banc Hyperfréquence”* on the following test configuration
  - RF attenuation simulated : σ0 = 0dB (AU Transceiver in Track function)

On the *“IHM ARINC429”*, check the height accuracy

(12) Measure the height accuracy at 250ft simulated for σ0 = 0dB
H_{true} ± (7,5ft)

- Set the *“Banc Hyperfréquence”* on the following test configuration
  - 1000ft simulated height
  - RF attenuation simulated : σ0 = -20dB (AU Transceiver in Track function)

Read the exact value of the 1000ft simulated height according to the last revision of the *“Banc Hyperfréquence”*

(13) Record the theoretical height at 1000ft simulated
***H_{true}* at 1000ft**

On the *“IHM ARINC429”*, check the height accuracy

(14) Measure the height accuracy at 1000ft simulated for σ0 = -20dB
H_{true} ± (50ft)

On the *“IHM ARINC429”*, check the statistical repartition of the observations

(15) Measure the statistical repartition of the observations at 1000ft simulated
≥ 95%

- Set the *“Banc Hyperfréquence”* on the following test configuration
  - RF attenuation simulated : σ0 = 0dB (AU Transceiver in Track function)

On the *“IHM ARINC429”*, check the height accuracy

(16) Measure the height accuracy at 1000ft simulated for σ0 = 0dB
H_{true} ± (50ft)

- Set the *“Banc Hyperfréquence”* on the following test configuration
  - 2000ft simulated height
  - RF attenuation simulated : σ0 = -20dB (AU Transceiver in Track function)

Read the exact value of the 2000ft simulated height according to the last revision of the *“Banc Hyperfréquence”*

(17) Record the theoretical height at 2000ft simulated
***H_{true}* at 2000ft**

On the *“IHM ARINC429”*, check the height accuracy

(18) Measure the height accuracy at 2000ft simulated for σ0 = -20dB
H_{true} ± (100ft)

On the *“IHM ARINC429”*, check the statistical repartition of the observations

(19) Measure the statistical repartition of the observations at 2000ft simulated
≥ 95%

- Set the *“Banc Hyperfréquence”* on the following test configuration
    - RF attenuation simulated : σ0 = 0dB (AU Transceiver in Track function)

On the *“IHM ARINC429”*, check the height accuracy

(20) Measure the height accuracy at 2000ft simulated for σ0 = 0dB
H_{true} ± (100ft)

- Set the *“Banc Hyperfréquence”* on the following test configuration
    - 5000ft simulated height
    - RF attenuation simulated : σ0 = -20dB (AU Transceiver in Track function)

Read the exact value of the 5000ft simulated height according to the last revision of the *“Banc Hyperfréquence”*

(21) Record the theoretical height at 5000ft simulated
H_{true} at 5000ft

On the *“IHM ARINC429”*, check the height accuracy

(22) Measure the height accuracy at 5000ft simulated for σ0 = -20dB
H_{true} ± (250ft)

On the *“IHM ARINC429”*, check the statistical repartition of the observations

(23) Measure the statistical repartition of the observations at 5000ft simulated
≥ 95%

- Set the *“Banc Hyperfréquence”* on the following test configuration
    - RF attenuation simulated : σ0 = 0dB (AU Transceiver in Track function)

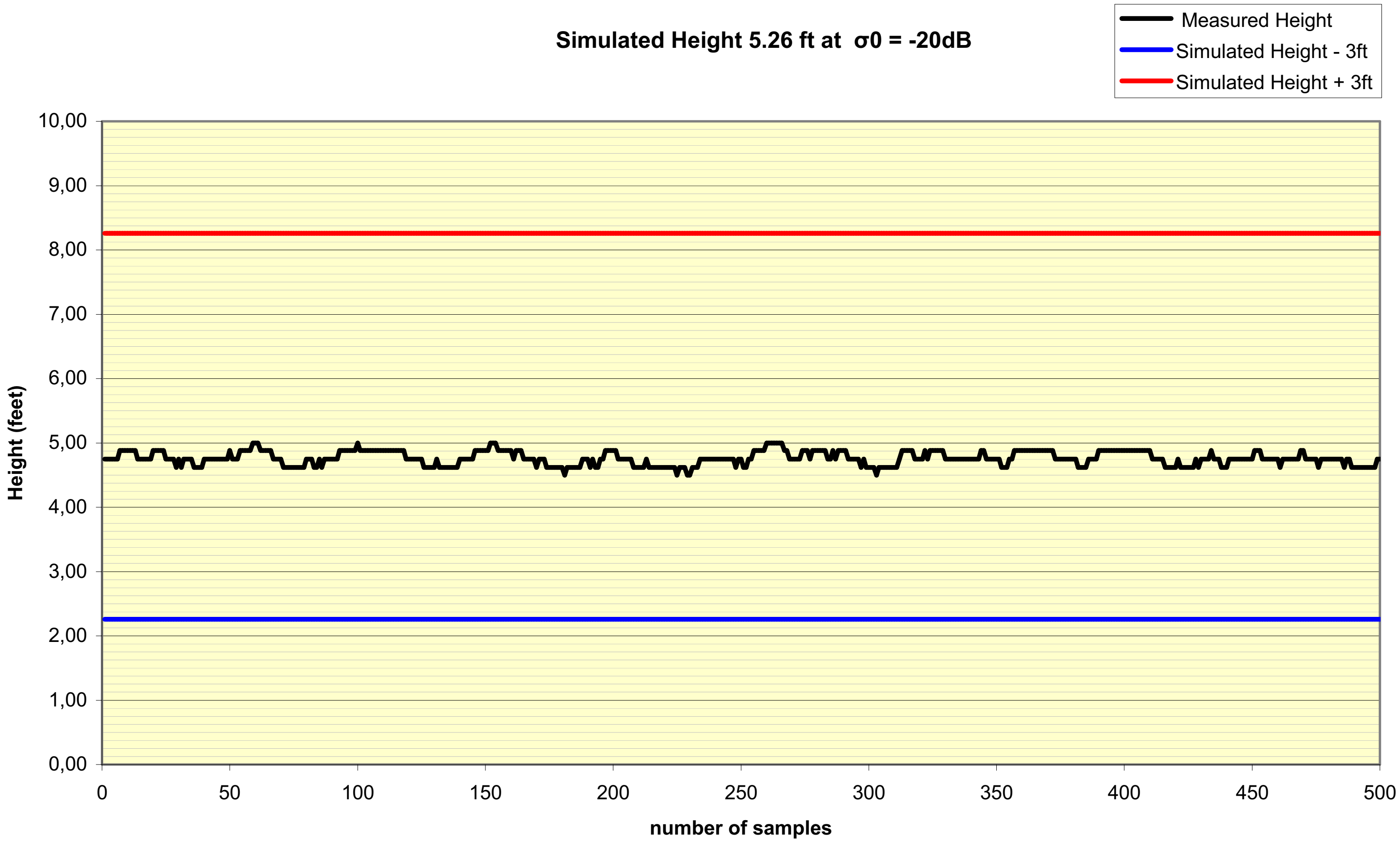
On the *“IHM ARINC429”*, check the height accuracy

(24) Measure the height accuracy at 5000ft simulated for σ0 = 0dB
H_{true} ± (250ft)

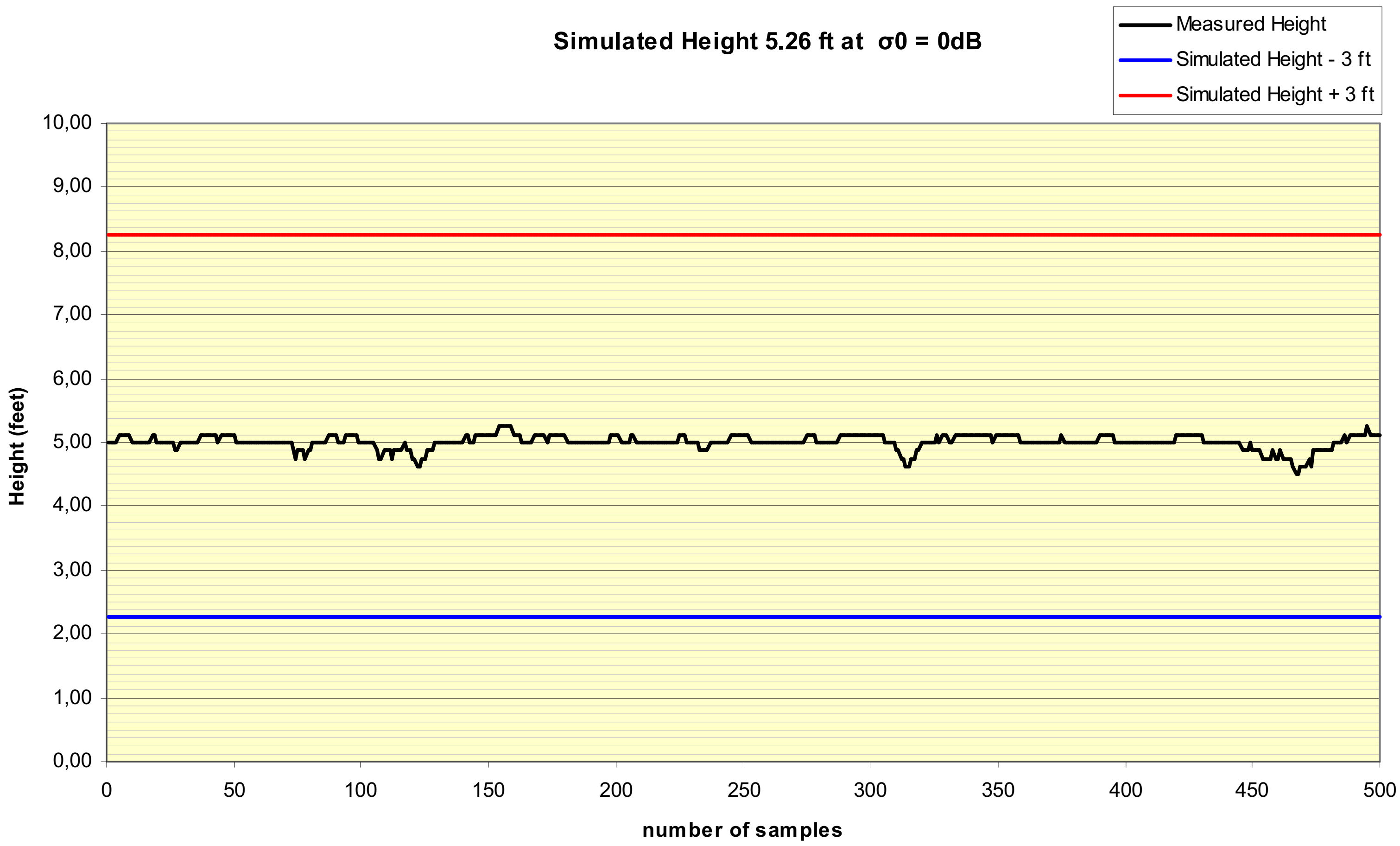
1.3 RESULTS

Performed checking	***Expected result***	***Result***
1. Record the theoretical height at AID simulated	**H_{true} = 5,26 ft**	4,75 ft
2. Measure the height accuracy at AID simulated for σ0 = -20dB	**H_{true} ± (3ft)**	OK
3. Measure the statistical repartition of the observations at AID simulated	**≥ 95%**	100%
4. Measure the height accuracy at AID simulated for σ0 = 0dB	**H_{true} ± (3ft)**	5ft

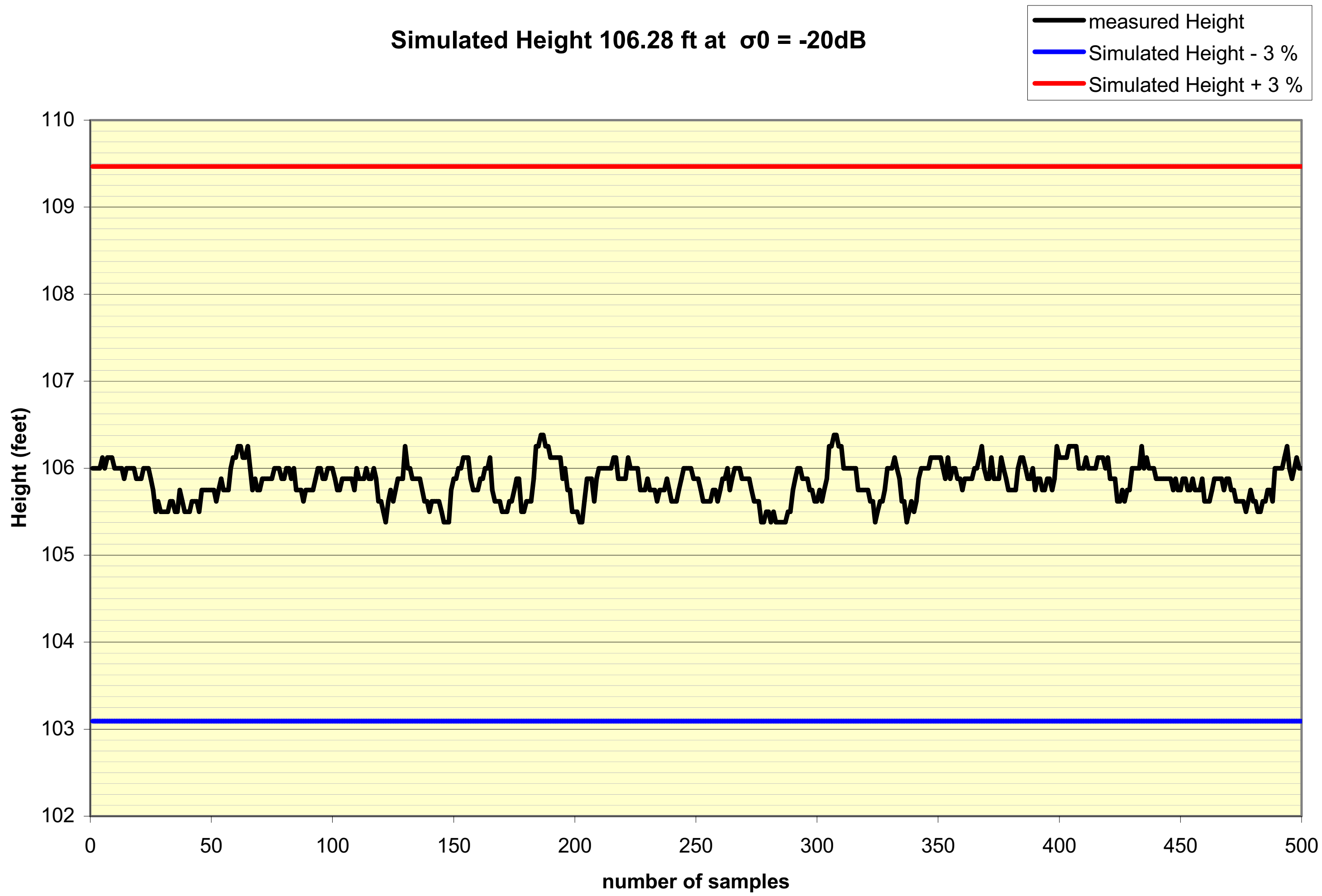
Performed checking	*Expected result*	*Result*
5. Record the theoretical height at 100ft simulated	**H_{true} = 106,28 ft**	105,38 ft
6. Measure the height accuracy at 100ft simulated for σ0 = -20dB	**H_{true} ± (3ft)**	OK
7. Measure the statistical repartition of the observations at 100ft simulated	**≥ 95%**	100%
8. Measure the height accuracy at 100ft simulated for σ0 = 0dB	**H_{true} ± (3ft)**	106,38 ft
9. Record the theoretical height at 250ft simulated	**H_{true} = 255,58 ft**	255,1 ft
10. Measure the height accuracy at 250ft simulated for σ0 = -20dB	**H_{true} ± (7,5ft)**	OK
11. Measure the statistical repartition of the observations at 250ft simulated	**≥ 95%**	100%
12. Measure the height accuracy at 250ft simulated for σ0 = 0dB	**H_{true} ± (7,5ft)**	254,75 ft
13. Record the theoretical height at 1000ft simulated	**H_{true} = 1004,98 ft**	986,5 ft
14. Measure the height accuracy at 1000ft simulated for σ0 = -20dB	**H_{true} ± (50ft)**	OK
15. Measure the statistical repartition of the observations at 1000ft simulated	**≥ 95%**	100%
16. Measure the height accuracy at 1000ft simulated for σ0 = 0dB	**H_{true} ± (50ft)**	1004,38 ft
17. Record the theoretical height at 2000ft simulated	**H_{true} = 2004,48 ft**	2009,38 ft
18. Measure the height accuracy at 2000ft simulated for σ0 = -20dB	**H_{true} ± (100ft)**	OK
19. Measure the statistical repartition of the observations at 2000ft simulated	**≥ 95%**	100%
20. Measure the height accuracy at 2000ft simulated for σ0 = 0dB	**H_{true} ± (100ft)**	2004,62
21. Record the theoretical height at 5000ft simulated	**H_{true} = 4999,98 ft**	5009,38 ft
22. Measure the height accuracy at 5000ft simulated for σ0 = -20dB	**H_{true} ± (250ft)**	OK
23. Measure the statistical repartition of the observations at 5000ft simulated	**≥ 95%**	100%
24. Measure the height accuracy at 5000ft simulated for σ0 = 0dB	**H_{true} ± (250ft)**	4995 ft

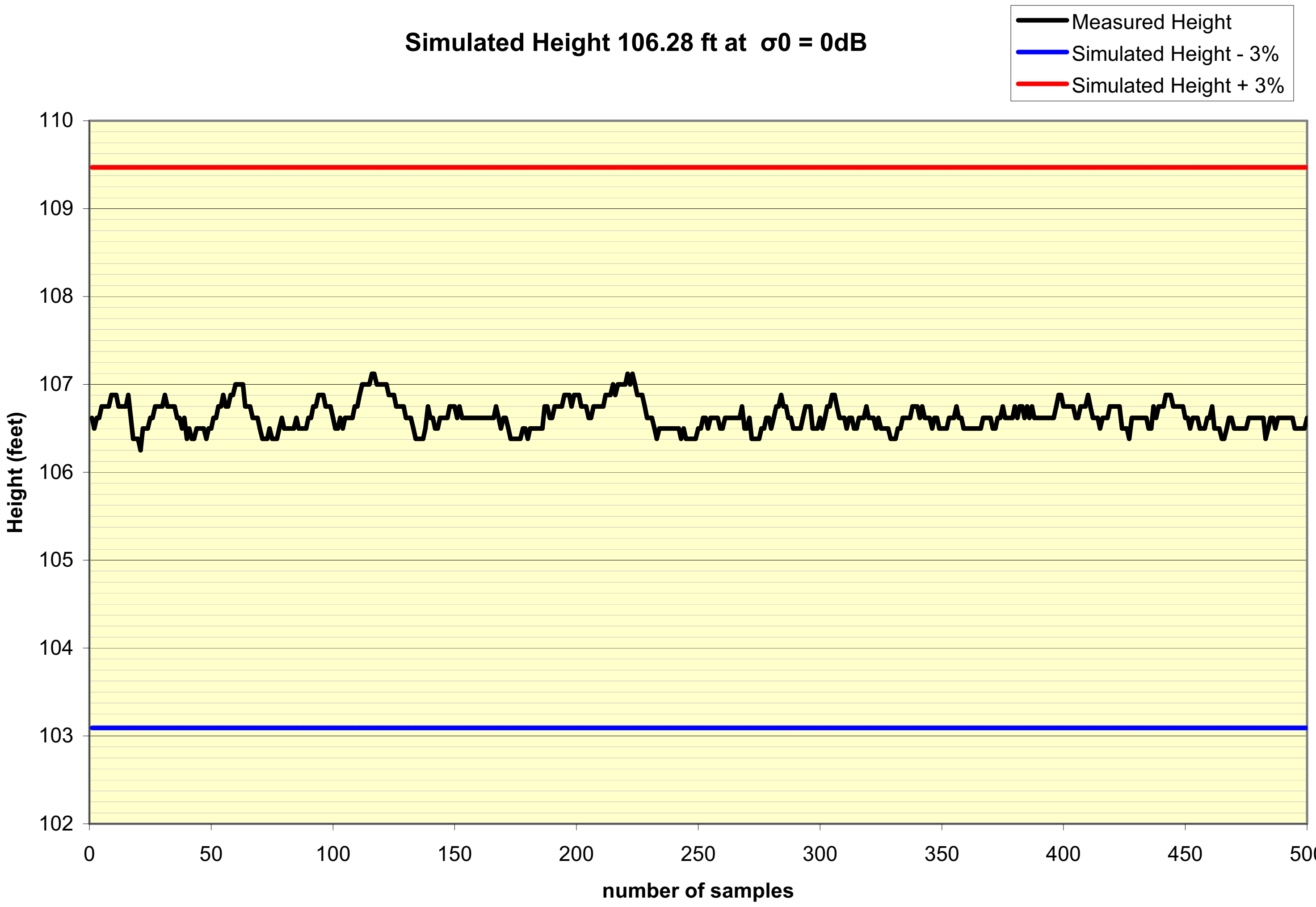


Simulated Height 5.26 ft at σ0 = -20dB
Measured Height
Simulated Height - 3ft
Simulated Height + 3ft
10,00
9,00
8,00
7,00
6,00
5,00
4,00
3,00
2,00
1,00
0,00
Height (feet)
0
50
100
150
200
250
300
350
400
450
500
number of samples

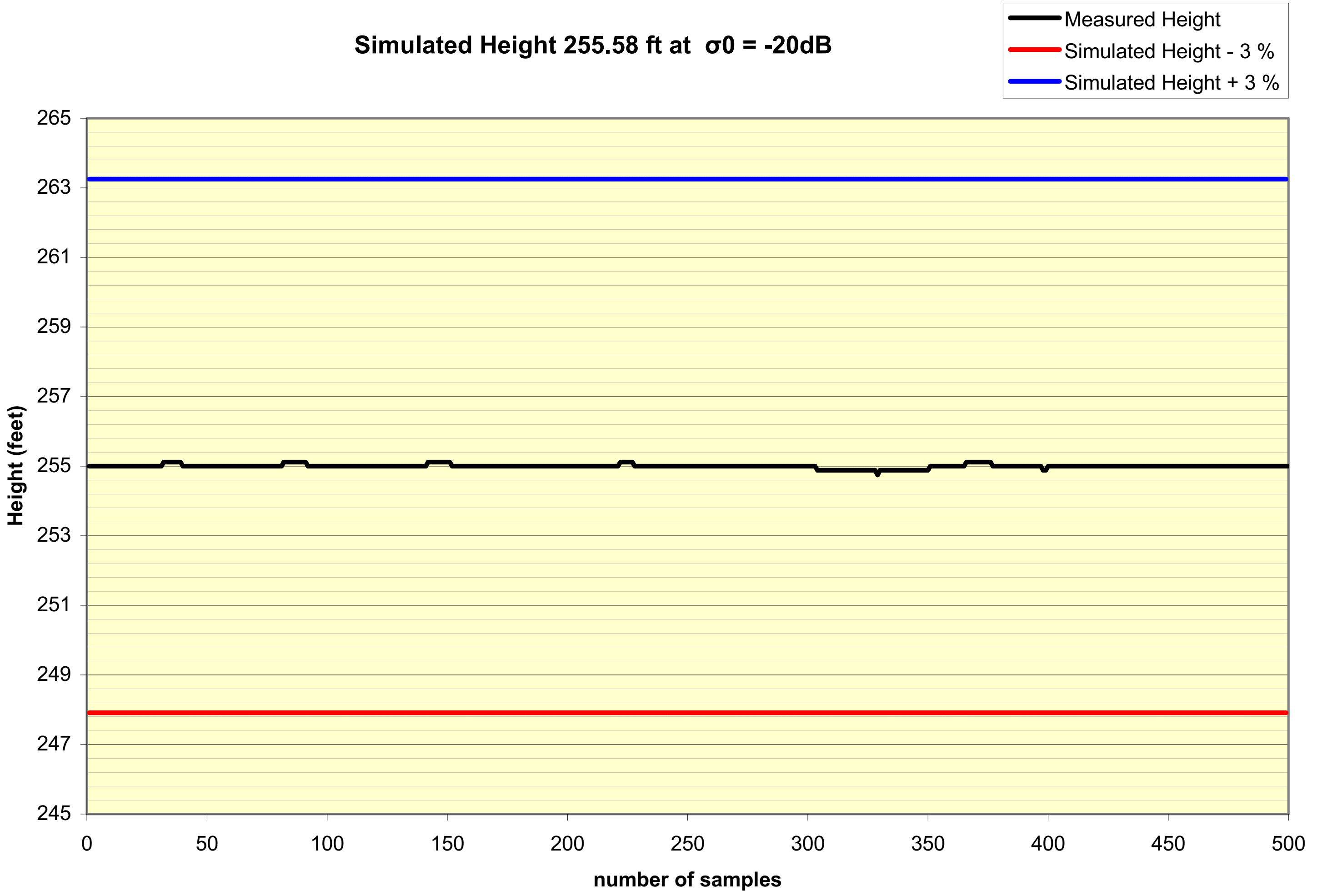


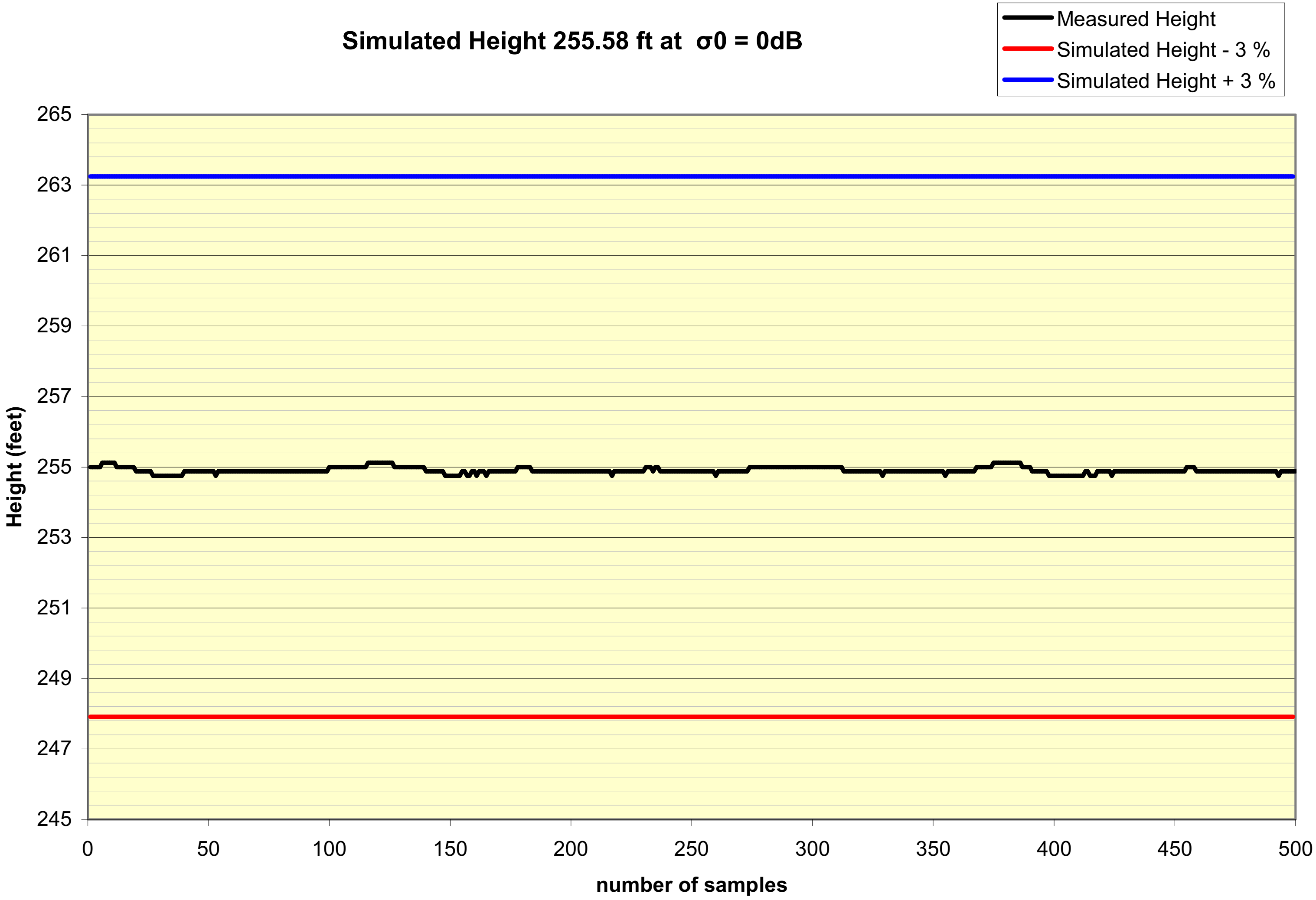
Simulated Height 5.26 ft at σ0 = 0dB
Measured Height
Simulated Height - 3 ft
Simulated Height + 3 ft
10,00
9,00
8,00
7,00
6,00
5,00
4,00
3,00
2,00
1,00
0,00
Height (feet)
0
50
100
150
200
250
300
350
400
450
500
number of samples

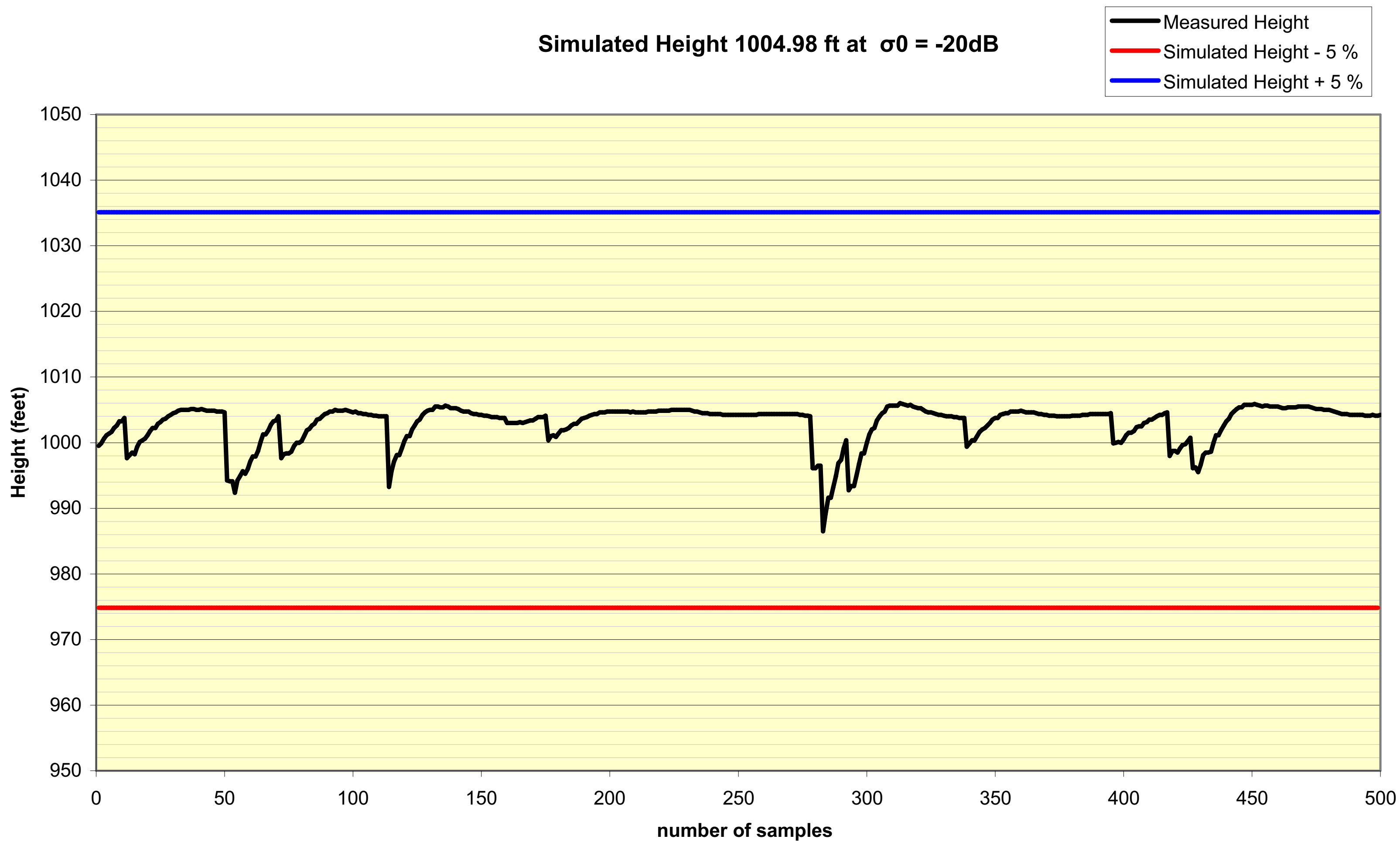

Simulated Height 106.28 ft at σ0 = -20dB
measured Height
Simulated Height - 3 %
Simulated Height + 3 %
110
109
108
107
106
105
104
103
102
Height (feet)
0
50
100
150
200
250
300
350
400
450
500
number of samples



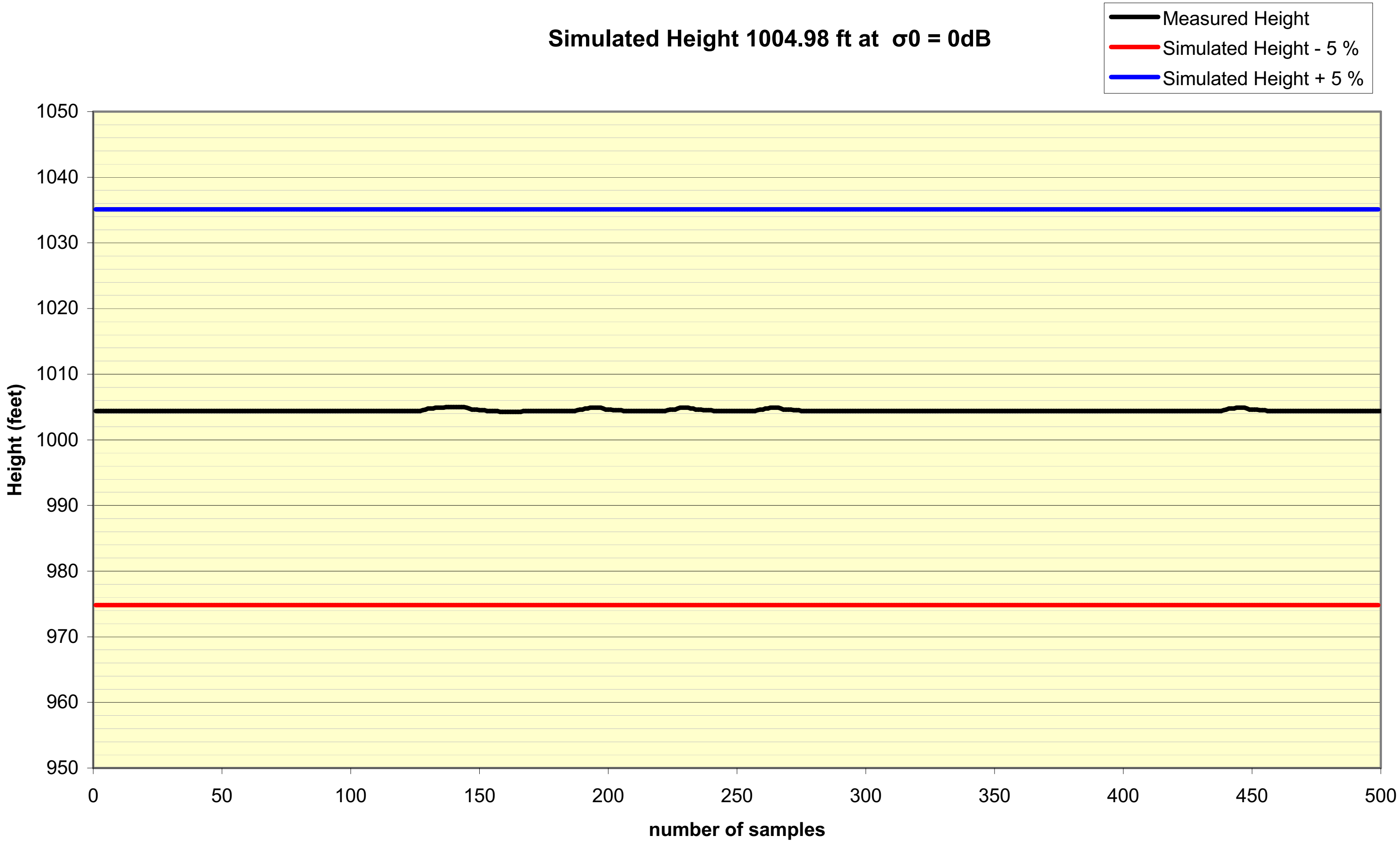
Simulated Height 106.28 ft at σ0 = 0dB
Measured Height
Simulated Height - 3%
Simulated Height + 3%
Height (feet)
110
109
108
107
106
105
104
103
102
0
50
100
150
200
250
300
350
400
450
500
number of samples

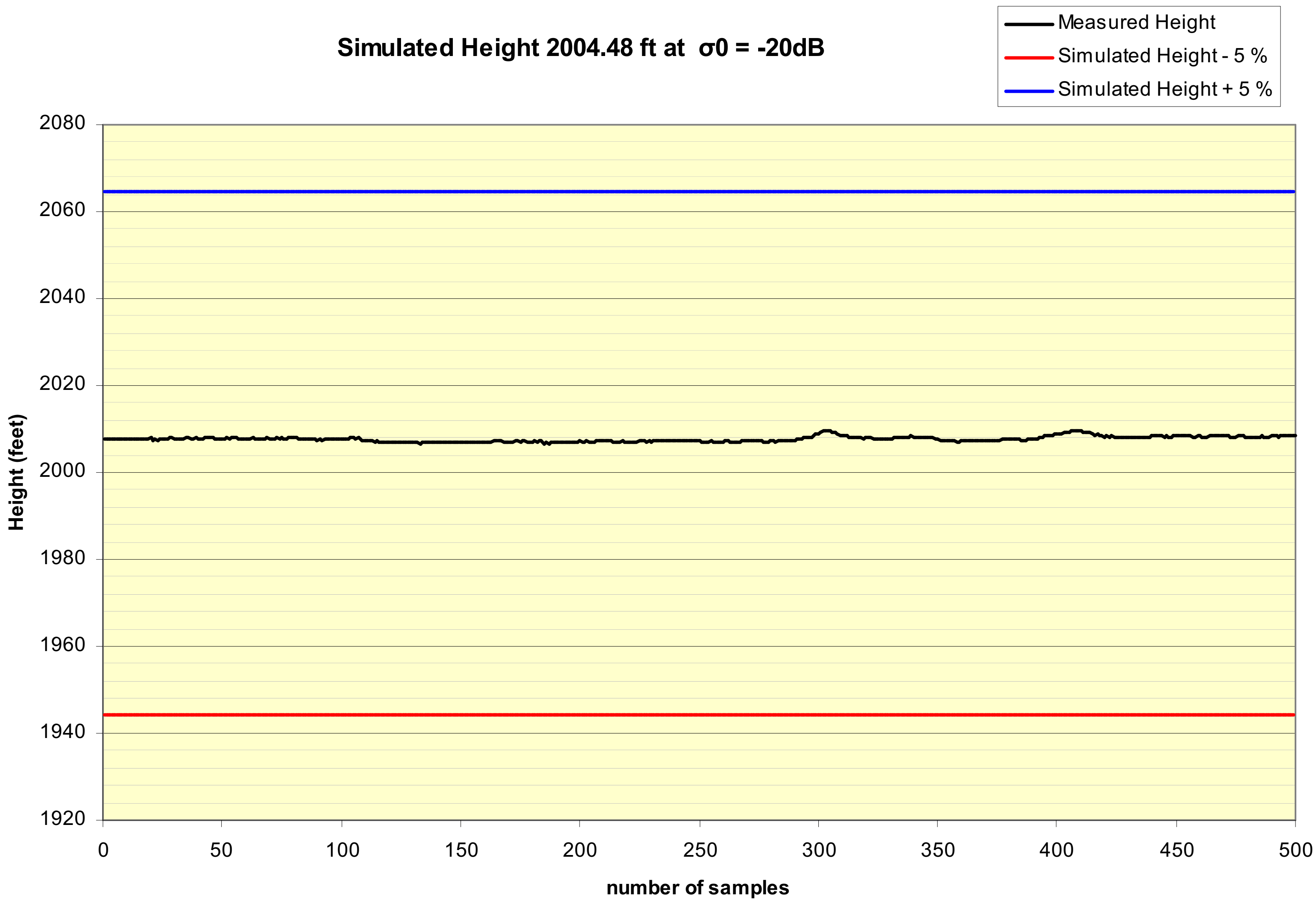

Simulated Height 255.58 ft at σ0 = -20dB
Measured Height
Simulated Height - 3 %
Simulated Height + 3 %
Height (feet)
265
263
261
259
257
255
253
251
249
247
245
0
50
100
150
200
250
300
350
400
450
500
number of samples

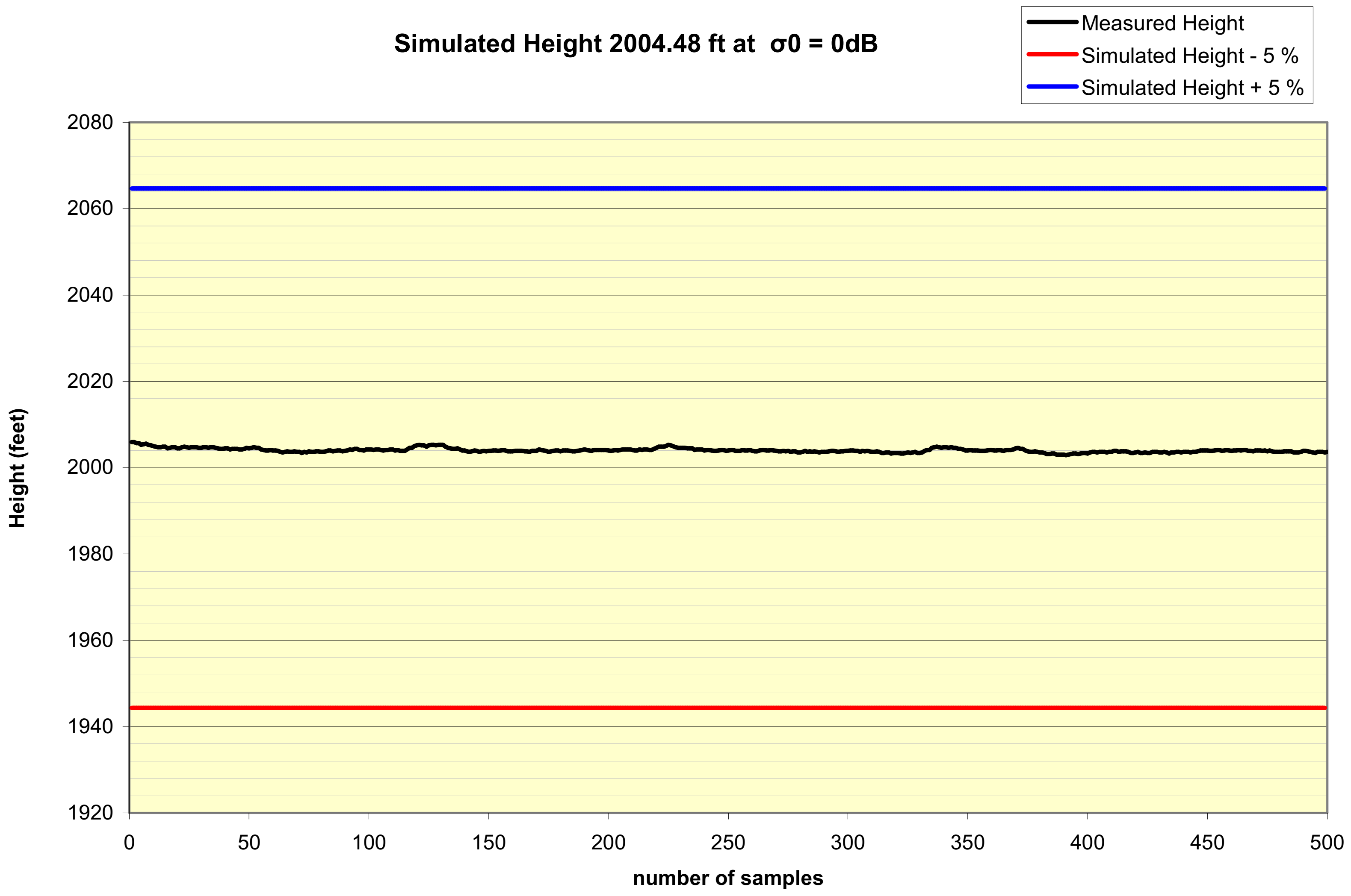

Simulated Height 255.58 ft at σ0 = 0dB
Measured Height
Simulated Height - 3 %
Simulated Height + 3 %
265
263
261
259
257
255
253
251
249
247
245
Height (feet)
0
50
100
150
200
250
300
350
400
450
500
number of samples



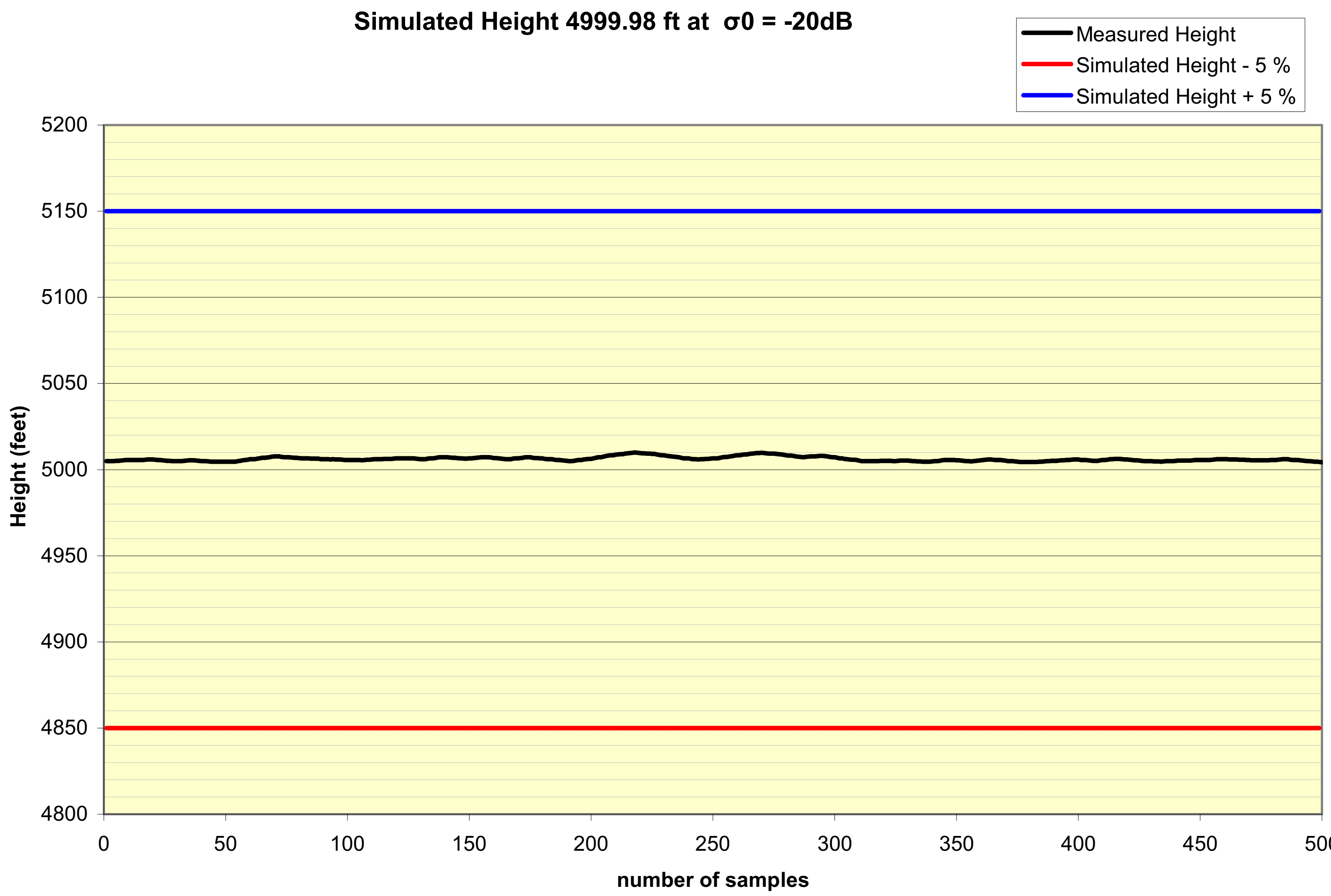
Simulated Height 1004.98 ft at σ0 = -20dB
Measured Height
Simulated Height - 5 %
Simulated Height + 5 %
Height (feet)
1050
1040
1030
1020
1010
1000
990
980
970
960
950
0
50
100
150
200
250
300
350
400
450
500
number of samples

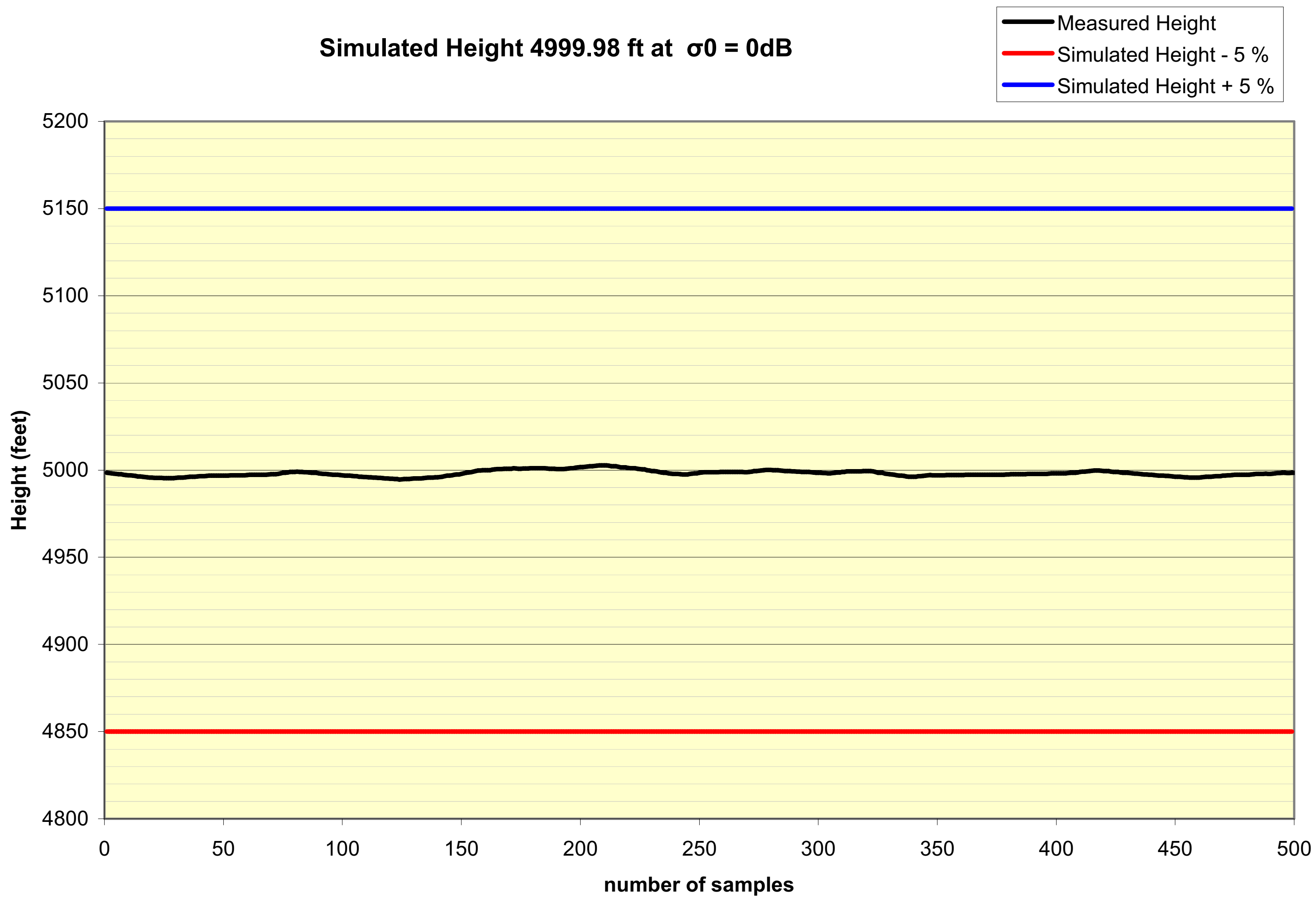

Simulated Height 1004.98 ft at σ0 = 0dB
Measured Height
Simulated Height - 5 %
Simulated Height + 5 %
1050
1040
1030
1020
1010
1000
990
980
970
960
950
Height (feet)
0
50
100
150
200
250
300
350
400
450
500
number of samples


Simulated Height 2004.48 ft at σ0 = -20dB
Measured Height
Simulated Height - 5 %
Simulated Height + 5 %
2080
2060
2040
2020
2000
1980
1960
1940
1920
Height (feet)
0
50
100
150
200
250
300
350
400
450
500
number of samples



Simulated Height 2004.48 ft at σ0 = 0dB
Measured Height
Simulated Height - 5 %
Simulated Height + 5 %
2080
2060
2040
2020
2000
1980
1960
1940
1920
Height (feet)
0
50
100
150
200
250
300
350
400
450
500
number of samples


Simulated Height 4999.98 ft at σ0 = -20dB
Measured Height
Simulated Height - 5 %
Simulated Height + 5 %
5200
5150
5100
5050
5000
4950
4900
4850
4800
Height (feet)
0
50
100
150
200
250
300
350
400
450
500
number of samples


Simulated Height 4999.98 ft at σ0 = 0dB
Measured Height
Simulated Height - 5 %
Simulated Height + 5 %
5200
5150
5100
5050
5000
4950
4900
4850
4800
Height (feet)
0
50
100
150
200
250
300
350
400
450
500
number of samples

2. FLIGHT TESTS

This document presents the justifications for the minimum performance standards for airborne low range radio altimeters TS0-C87 and more particularly for the in-flight conditions.

– <u>Accuracy of height information output :</u> from 3 to 100 ft accuracy shall be better than ± 3 ft,
  from 100 to 500 ft accuracy shall be better than ± 3% of height,
  above 500 ft accuracy shall be better than ± 5% of height.

The flight test have been carried on an helicopter Bell-47 G2.

Height given by the radio altimeter is compared to the reference provided by a laser telemeter LD-90-3 RIEGL..

2.1 DEMONSTRATION

Curves below show in blue the radio altimeter height issue from the record of the ARINC data (label 164), in cyan the reference value, in red the upper limit and in green the lower limit. Curves correspond to measure at different height over different terrain.

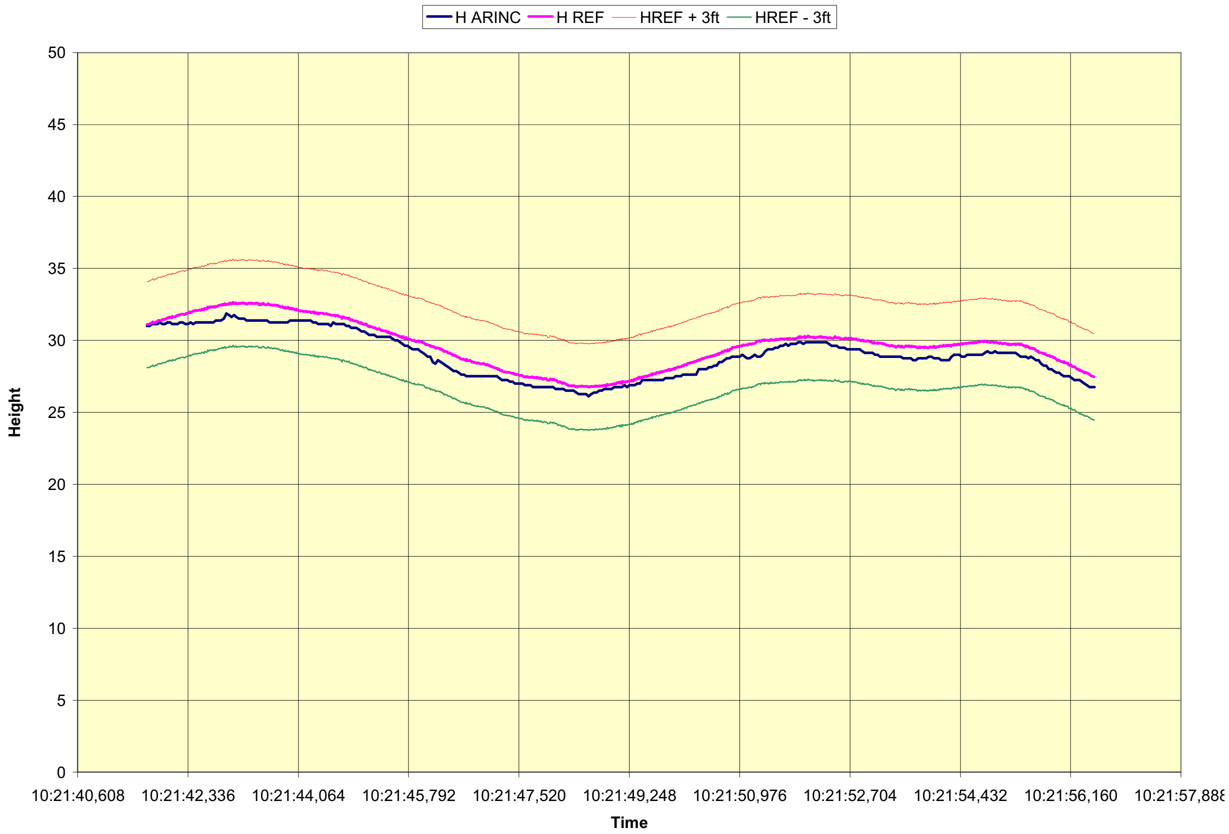


Figure 1 : Flight at 30 ft over asphalt

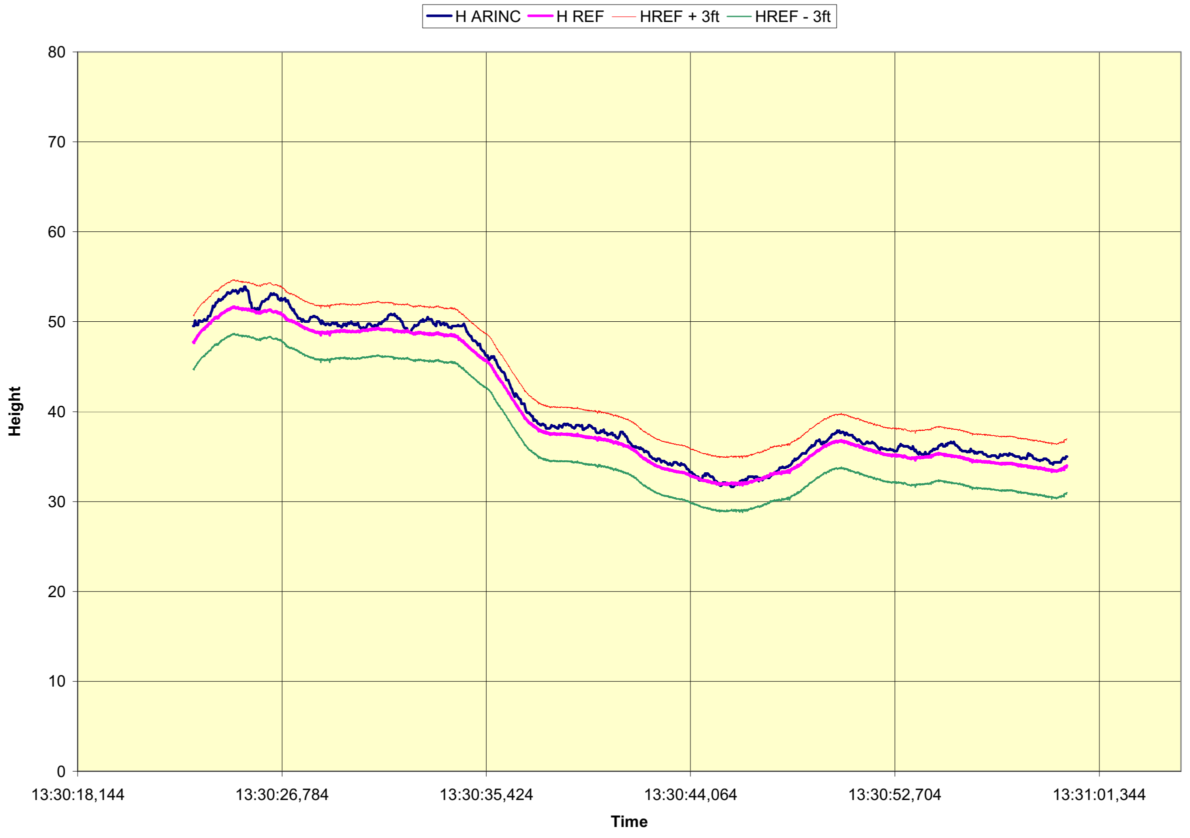


Figure 2 : Flight at 50 ft over grass

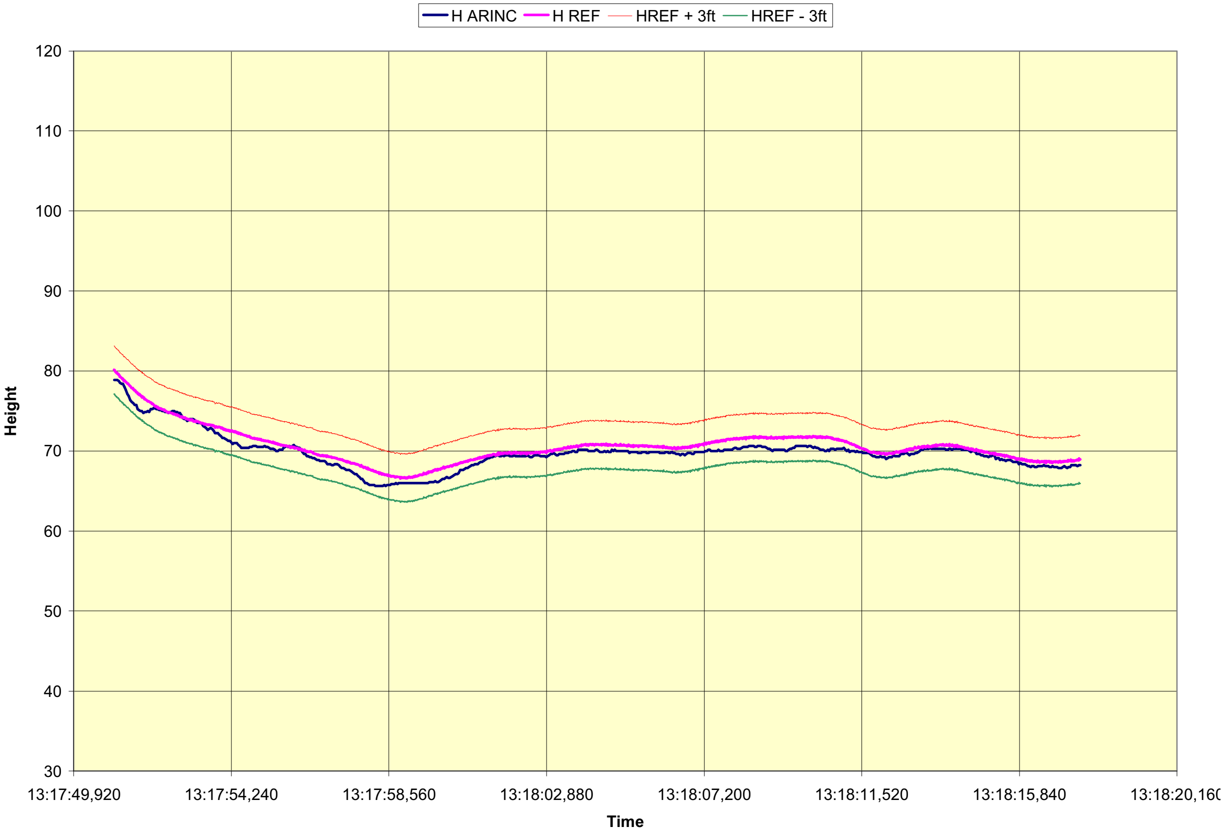


Figure 3 : Flight at 80 ft over asphalt

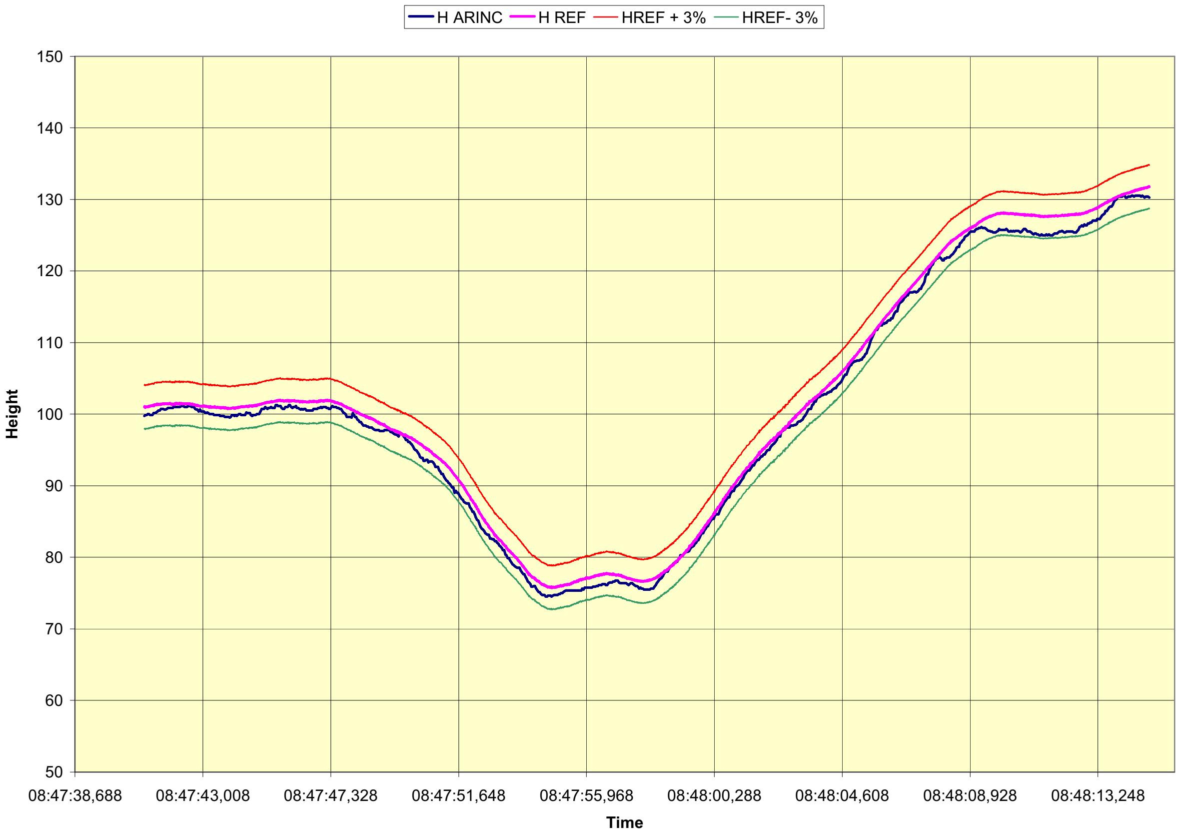


Figure 4 : Flight at 100 ft over asphalt

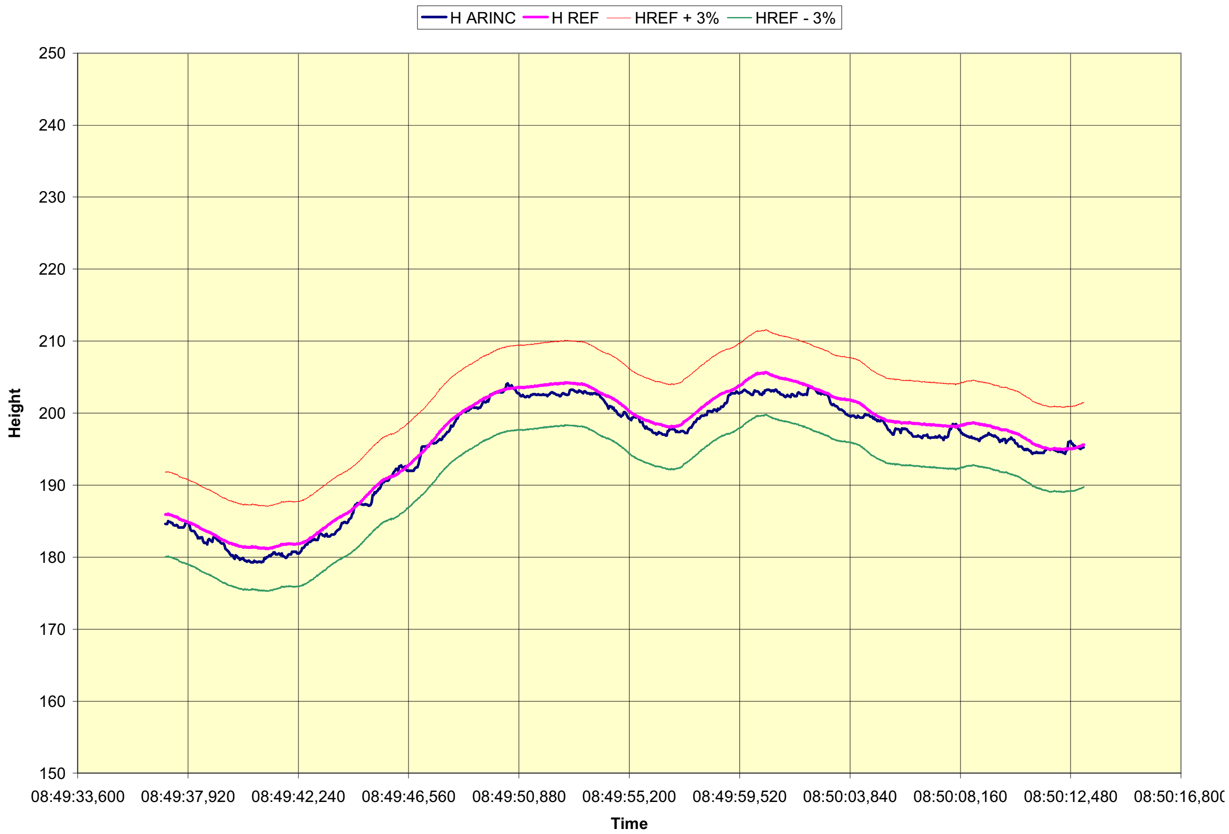


Figure 5 : Flight at 200 ft over asphalt

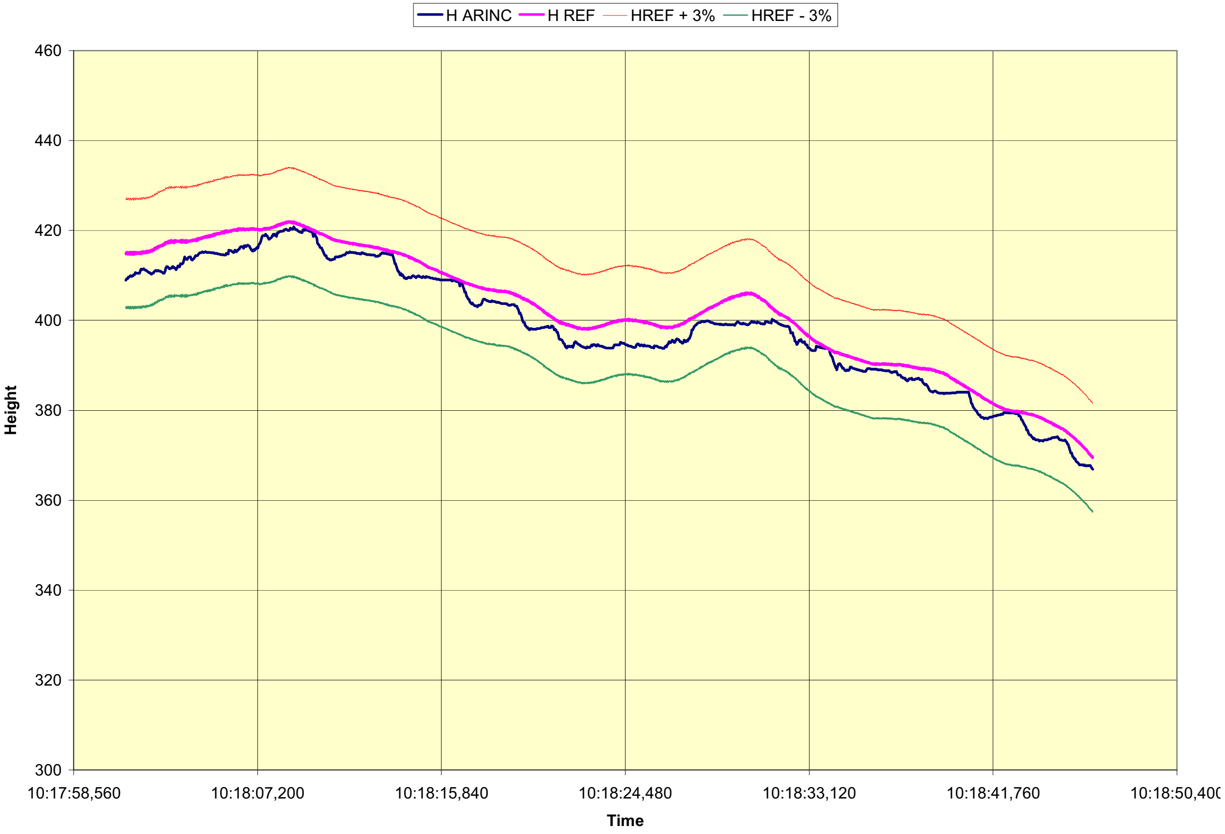


Figure 6 : Flight at 400 ft over grass

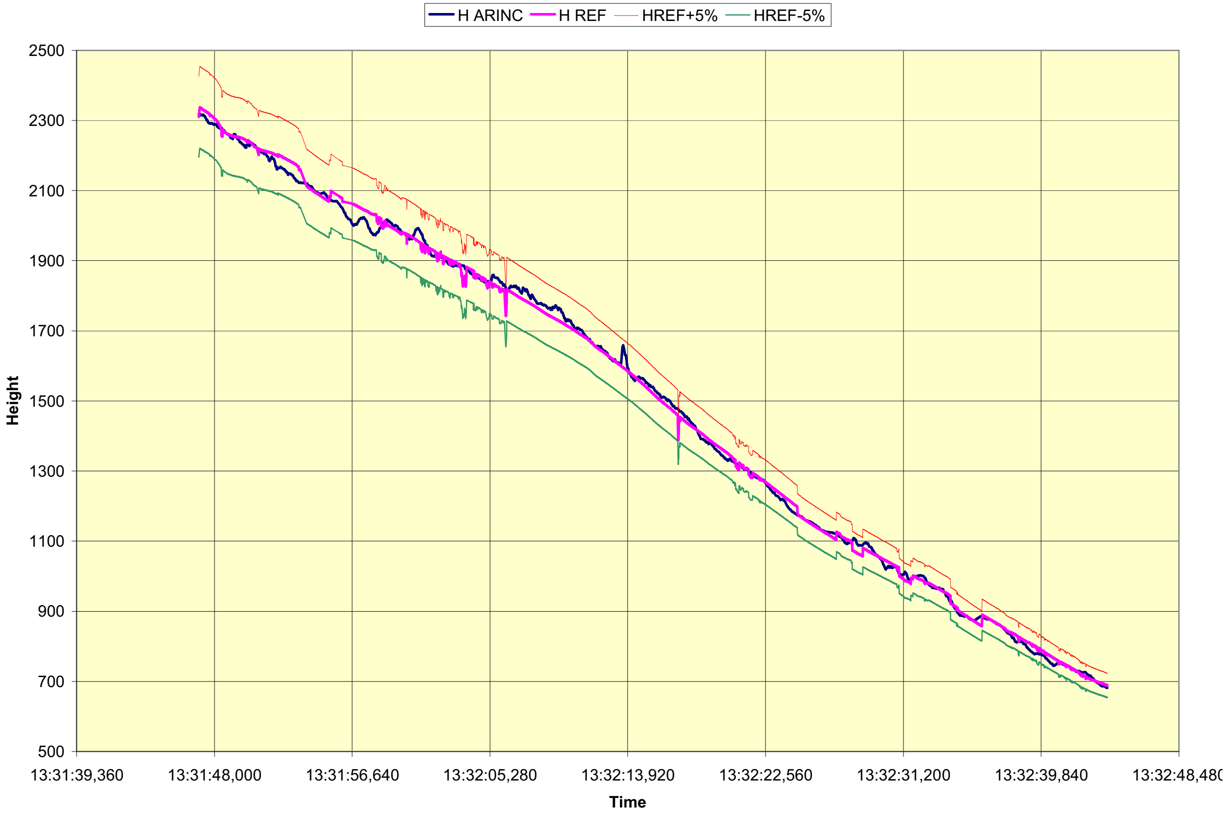


Figure 7 : Climb from 2300 ft to 700 ft over cultivation with urban areas

Flight trials demonstrate that AHV1600 radio altimeter is compliant with the accuracy requirements

Altitude noise

1. PREPARATION OF THE TESTS

1.1 LABORATORY TEST DEVICE

1.1.1 STANDARD LABORATORY TEST EQUIPMENT

Name	***Manufacturer name***	***Type***	Serial number	Validity expiration
ARINC429 transmitter / receiver	JCAIR	429E	393606	None
DC Power supply	TTI	EL302D	TH102492	None

1.1.2 SPECIAL LABORATORY TEST EQUIPMENT

Name	***Part number***	***Serial number***	***Validity expiration***
“Banc système”	62 057 140 AA	00001	-
“Banc Hyperfréquence”	61 488 676 AA	SN102	30/2009

2. PROCEDURE

For each simulated height up to 100 ft : 5ft, 100ft for σ0 = -20dB (AU Transceiver in Track function) :

(1) Record for 20 s the height output

(2) Compute the mean value of the height : $$\overline{H} = \frac{1}{N}\sum_{i=1}^{N} H_i$$

(3) Compute the RMS value of the noise : $$Noise_{RMS} = \sqrt{\frac{1}{N}\sum_{i=1}^{N}\left(\overline{H} - H_i\right)^2}$$

3. RESULTS

These results are based on the recording done for "Altitude Accuracy and loop gain".

Performed checking	***Expected result***	***Result***
1. Record the theoretical height at AID simulated	**H_{true} = 5,26 ft**	4,75 ft
2. Compute the mean value of the height at AID	**-**	5,01 ft
3. Compute the RMS value of the noise at AID	**<0,25 ft**	0,115 ft
4. Record the theoretical height at 106ft simulated	**H_{true} = 106,28 ft**	105,38 ft
5. Compute the mean value of the height at 106ft	**-**	106,64 ft
6. Compute the RMS value of the noise at 106ft	**<0,25 ft**	0,157 ft

Time constant

1. PREPARATION OF THE TESTS

1.1 LABORATORY TEST DEVICE

1.1.1 STANDARD LABORATORY TEST EQUIPMENT

Name	***Manufacturer name***	***Type***	Serial number	Validity expiration
ARINC429 transmitter / receiver	JCAIR	429E	393606	None
DC Power supply	TTI	EL302D	TH102492	None

1.1.2 SPECIAL LABORATORY TEST EQUIPMENT

Name	***Part number***	***Serial number***	***Validity expiration***
“Banc système”	62 057 140 AA	00001	-
“Banc Hyperfréquence”	61 488 676 AA	SN102	30/2009

2. PROCEDURE

Height step response time:

- Set the *“Banc Hyperfréquence”* on the following test configuration
  - 100ft simulated height
  - RF attenuation simulated : $\sigma 0$ = -10dB (AU Transceiver in Track function)
  - 110ft simulated height
  - RF attenuation simulated : $\sigma 0$ = -10dB (AU Transceiver in Track function)

Read the exact value of the simulated height according to the last revision of the *“Banc Hyperfréquence”*

(1) Record the theoretical height at 100ft simulated
H_{true} at 110ft

(2) Record the theoretical height at 120ft simulated
H_{true} at 122ft

- Set the *"Banc Hyperfréquence"* on the following test configuration
    - 110ft simulated height
- With the *"IHM ARINC429",* record the label "164"
- Switch the *"Banc Hyperfréquence"* on the following test configuration
    - 122ft simulated height

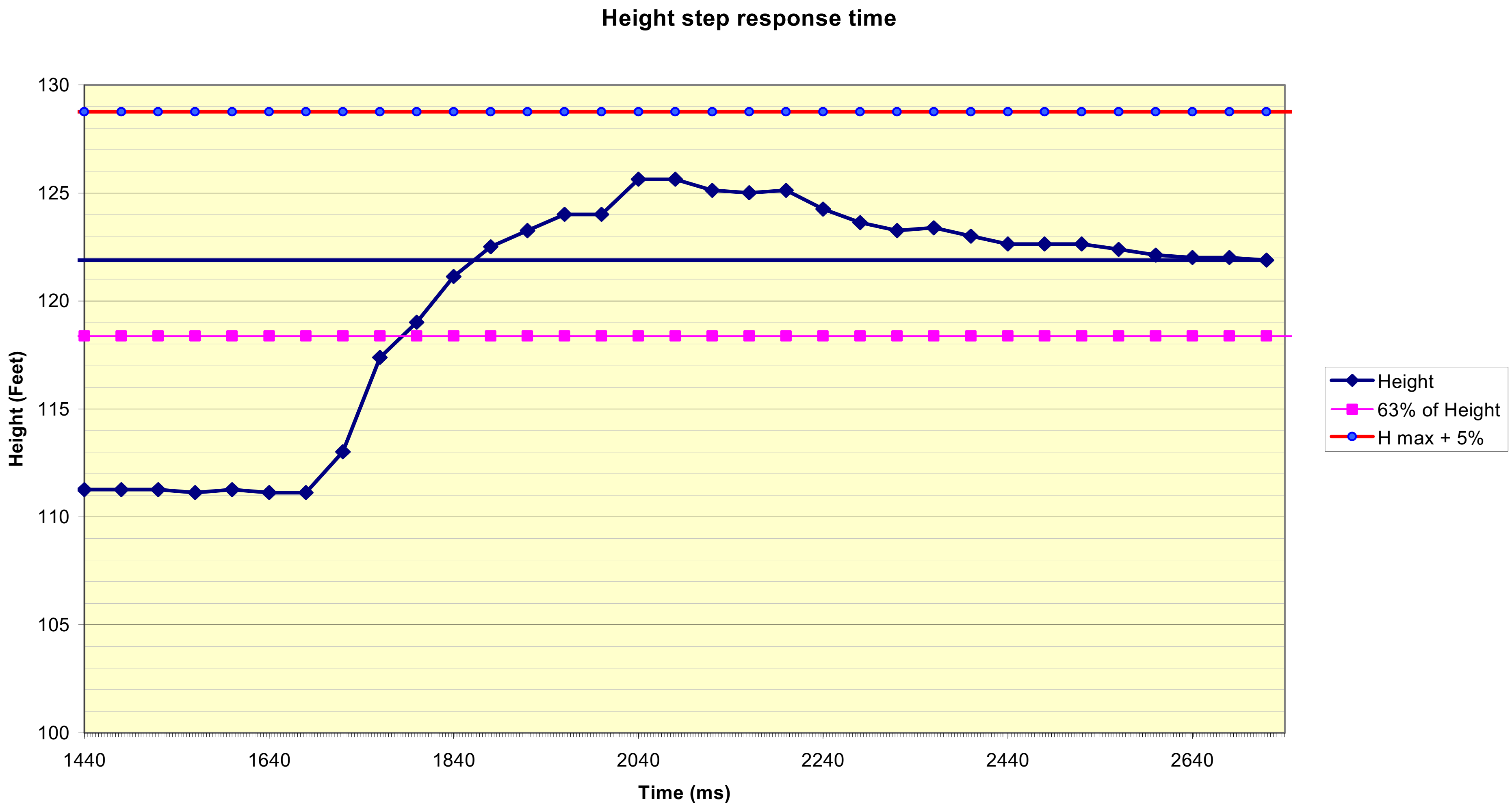
On the recording of the *"IHM ARINC429",* check the "height data" response time to reach 63% of the height step

(3) Measure the height step response time
T ≤ 0.1s

(4) Measure the overshoot < 5% of the true height

3. RESULTS

Performed checking	*Expected result*	*Result*
1. Record the theoretical height at 100ft simulated	**H_{true} = 110 ft**	111ft
2. Record the theoretical height at 120ft simulated	**H_{true} = 122 ft**	122ft
3. Measure the height step response time	**T ≤ 0.1s**	90ms
4. Measure the overshoot	**< 5% of Htrue**	2,4%


Height step response time
130
125
120
115
110
105
100
Height (Feet)
1440
1640
1840
2040
2240
2440
2640
Time (ms)
Height
63% of Height
H max + 5%