	Centre National d'Etudes Spatiales	
MAD_RAD_02 TRO-NT-32-NT-2817-CNES	Activity : CAL/VAL MADRAS Radiometric Sensitivity	Prepared by : C.Goldstein Verified by : N Karouche

Contents

1. OBJECTIVE

The main goal of this document is to verify the compliance of the radiometric sensitivity performances to the requirements of all the MARFEQ (MAdras RF Equipment) channels.

The global survey of the radiometric sensitivity from launch up to orbit 6700 is given.

An estimation of Receiver temperature and Noise Factor of each channel is given since launch.

A measurement of the radiometric sensitivity for the cold calibration is given for one orbit.

Finally, an estimation of the radiometric sensitivity for variable brightness temperature is given for each channel.

2. METHODS

From a theoretical point of view, the radiometric sensitivity ΔT is defined as follows:

$$(\Delta T)^2 = T_{Sys}{}^2 \chi \left(\frac{1}{B\tau} + \left(\frac{\Delta G}{G} \right)^2 \right) + X^2$$

With B = channel predetection bandwidth,

τ = integration time,

G = receiver gain,

ΔG/G gain stability over the integration time,

T*sys* = T*antenna* +T*receiver* equivalent temperature collected at the receiver input. Treceiver includes feed temperatures.

X^2 corresponds to the quantization effects and noise contributions on analog signals before digital encoding.

This formula allows to define the global requirement and declines an allocation to the different contributor.

From a practical point of view, the radiometric sensitivity is the result of the computation of the standard deviation of a series of samples delivered by the receiver chain output measuring an antenna temperature as specified (T_A) with a sampling equals to the integration time τ.

In flight conditions, this measurement is realized on the valid samples of the hot calibration window whose temperature is closed to the ambient temperature of the ground reference measurement.

3. SUCCESS CRITERIA

The success criteria is the requirements, defined at samples and pixels levels, as expressed in MARFEQ technical requirements.

At pixel level, the requirements are:

Channel	Goal design	Requirement	Dwell time
M1	0,5K	<0,7K	16,8ms
M2	0,5K	<0,7K	16,8ms
M3	0,5K	<0,7K	16,8ms
M4	1,0K	<1,1K	4,2ms
M5	2,0K	<2,6K	2,5ms

At samples level, the requirements are:

Channel	Requirement	Integration time
M1	0,95K	8ms
M2	0,95K	8ms
M3	0,95K	8ms
M4	1,4K	2ms
M5	3,5K	1ms

4. PRODUCTS USED

The measurement of the radiometric sensitivity performances are based on the result of the periodic survey realised each 100 orbits (7 days) since launch.

The measurement of the radiometric sensitivity in cold calibration is realised on orbit 738.

The estimation of the radiometric sensitivity for variable brightness temperature is based on the interpolation of hot and cold samples of the orbit 738.

5. RESULTS

5.1. RADIOMETRIC SENSITIVITY PERFORMANCES

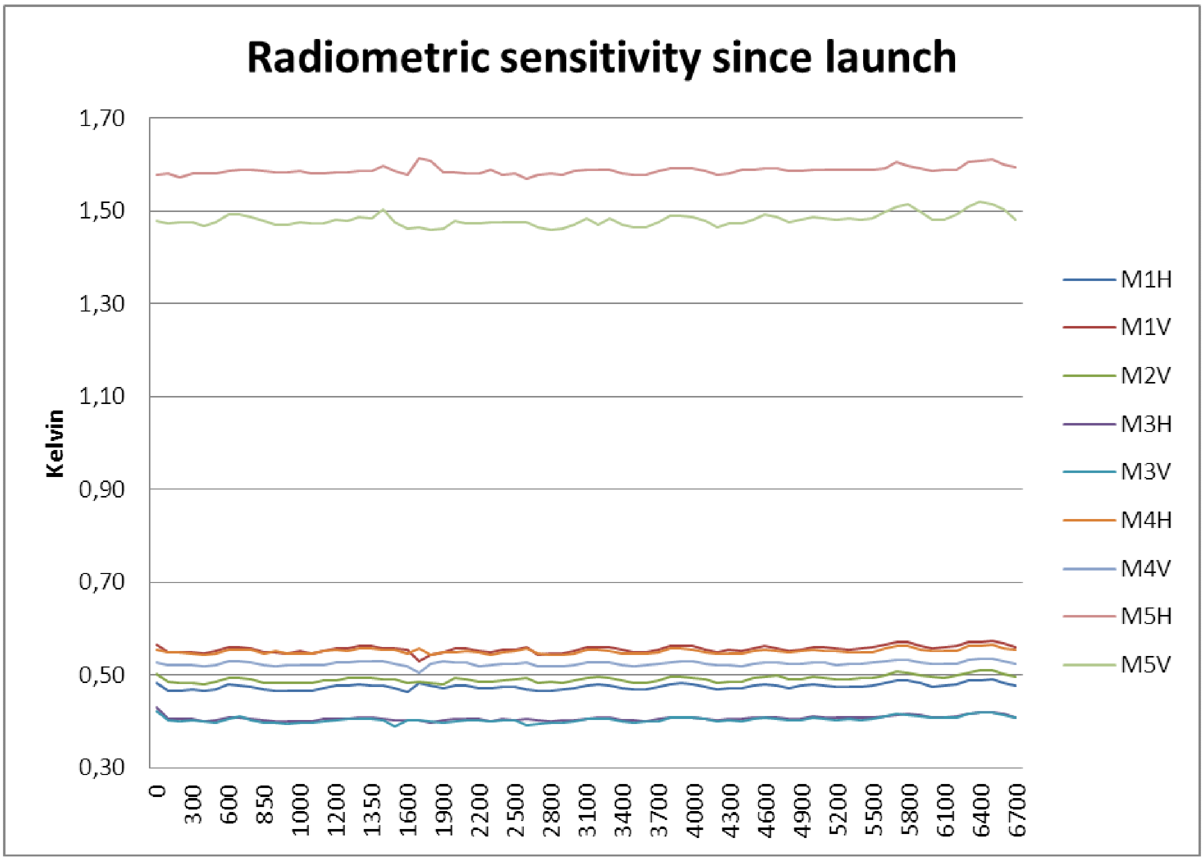
The chart hereunder shows the radiometric sensitivity for all the MARFEQ channels:

	M1H	**M1V**	**M2V**	**M3H**	**M3V**	**M4H**	**M4V**	**M5H**	**M5V**
Samples Tint	8ms	8ms	8ms	8ms	8ms	2ms	2ms	1ms	1ms
Spécification °K	0,95	0,95	0,95	0,95	0,95	1,4	1,4	3 ,5	3,5
Ground	0,54	0,64	0,57	0,46	0,48	0,59	0,56	1,71	1,70
Flight	0,48	0,56	0,49	0,40	0,40	0,55	0,53	1,59	1,49
Pixel Tint	16,8ms	16,8ms	16,8ms	16,8ms	16,8ms	4,2ms	4,2ms	2,5ms	2,5ms
Spécification °K	0,7	0,7	0,7	0,7	0,7	1,1	1,1	2,6	2, 6
Flight	0,33	0,38	0,34	0,28	0,28	0,38	0,36	1,01	0,94

Comments:

- The flight results at sample level are measurements. The better performances observed in flight wrt ground measurement in the same conditions is commonly observed on microwave radiometer (vacuum conditions more efficient for this type of instrument).
- The results at Pixel levels are issued of a simple extrapolation of the sample level based on the gain due to the increase of integration time.
- In any case, the margin wrt specifications is comfortable after 15 months of operation. At the moment, global performances are still better than the design goal.

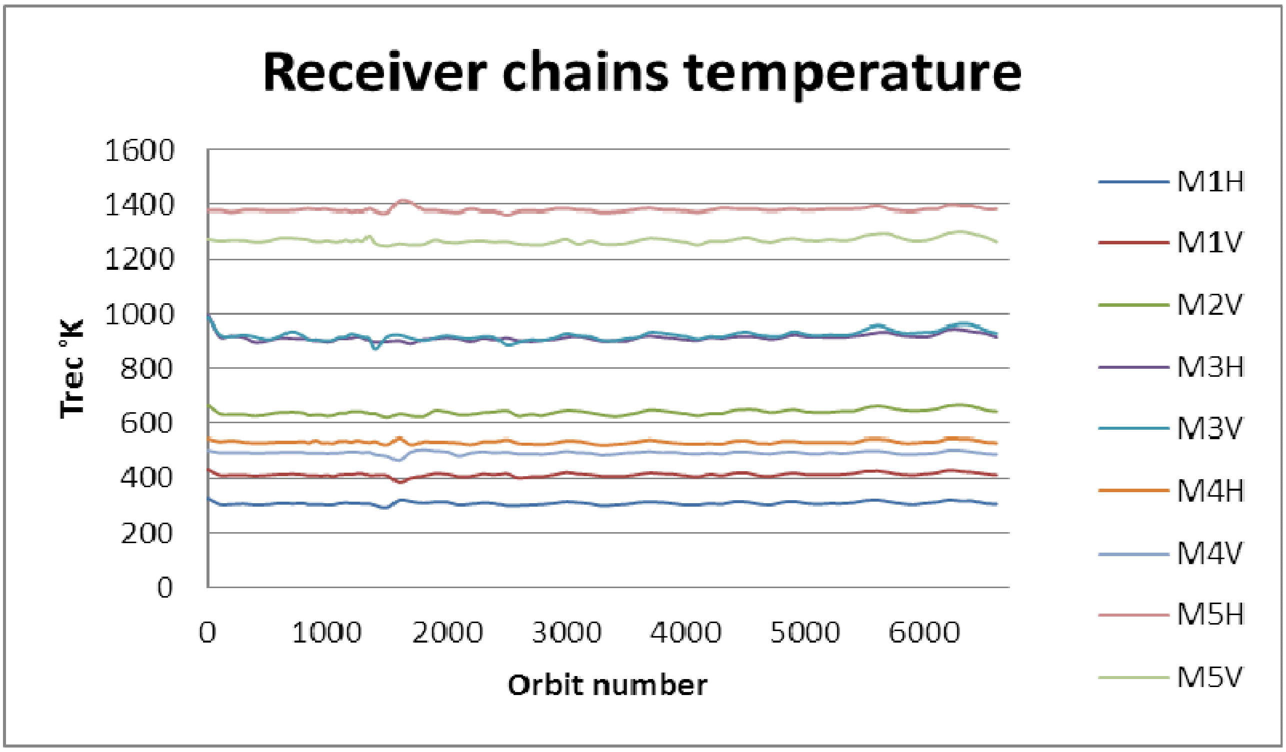
5.2. GLOBAL SURVEY SINCE LAUNCH



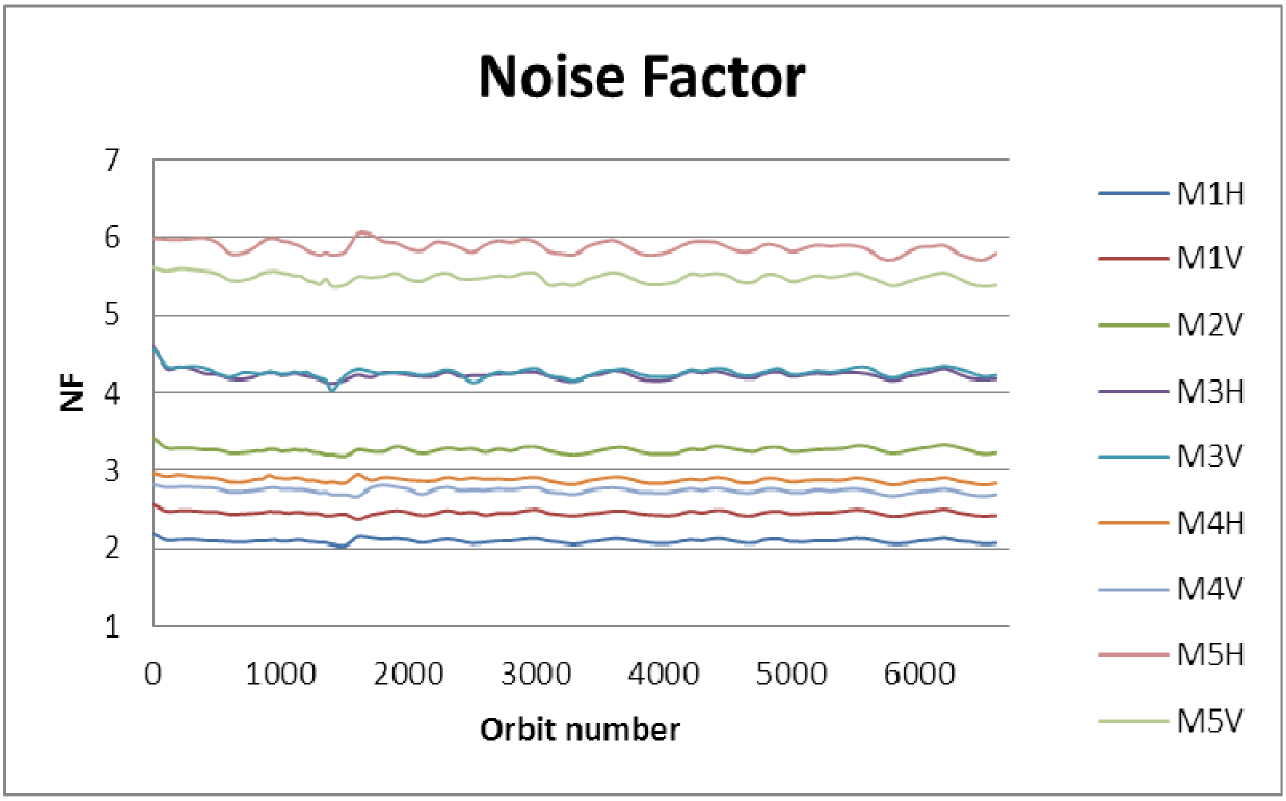
The figure shows the variation of the radiometric sensitivity of all MADRAS channels since launch. The performances are extremely stable

5.3. ESTIMATION OF RECEIVER TEMPERATURE AND NOISE FACTOR FOR EACH CHANNEL

An estimation of the receiver temperature for each channel is realised by simple inversion of the theoretical formula:



The Noise Factor is then derived



These estimations are better than the last pre-flight prediction based on ground measurement and BOL thermal conditions.

Nota: The receiver temperature as computed here includes the receiver temperature but also all the passive losses before the receiver (feed, polarisation demultiplex, waveguide, coaxial cable).

5.4. RADIOMETRIC SENSITIVITY IN COLD CONDITIONS

A specific analysis is led on orbit 738 to show the difference between the radiometric sensitivity in hot and cold conditions:

Channel	M1H	M1V	M2V	M3H	M3V	M4H	M4V	M5H	M5V
Tant= 287K	0,48	0,56	0,49	0,41	0,40	0,55	0,53	1,59	1,49
Tsky	0,26	0,34	0,35	0,31	0,31	0,39	0,34	1,34	1,22

This is a simple verification on measurement data of an obvious result: Lower is the system temperature $T_{sys=}$ (T_{rec} + T_A) better is the radiometric sensitivity.

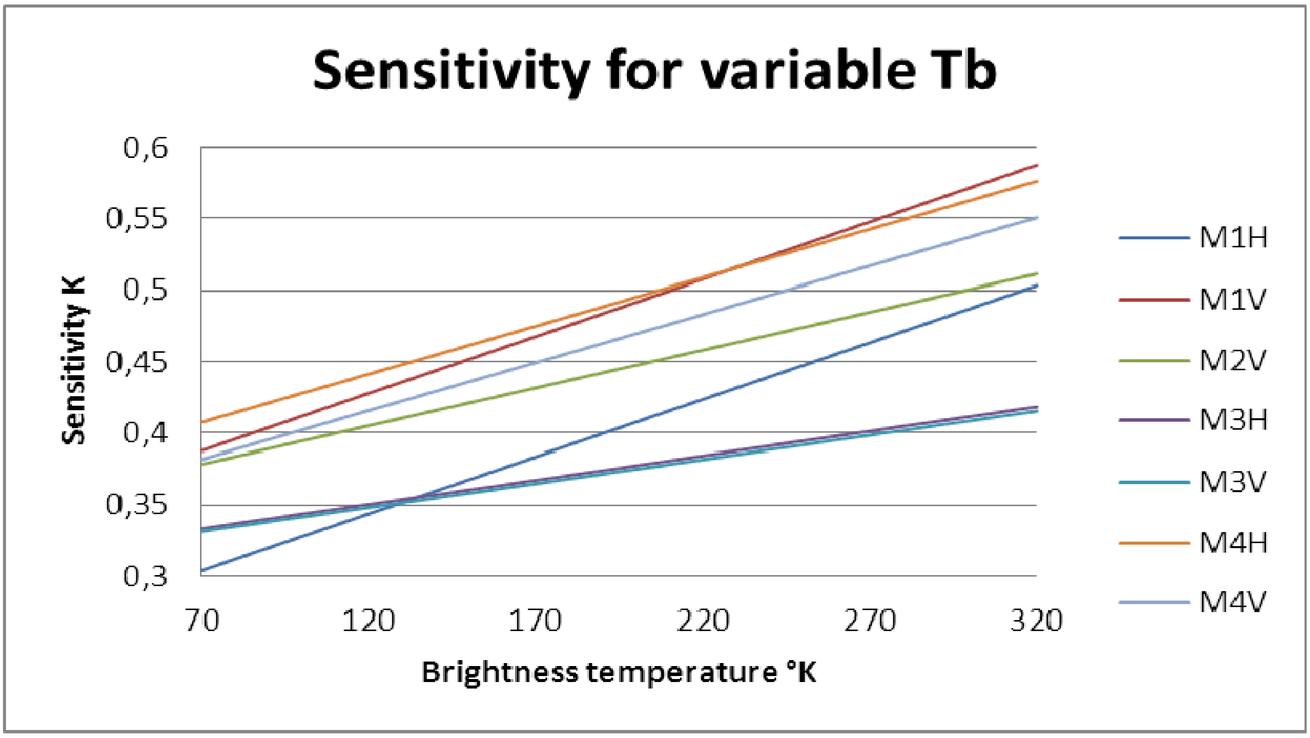
5.5. ESTIMATION OF THE RADIOMETRIC SENSITIVITY FOR VARIABLE BRIGHTNESS TEMPERATURE

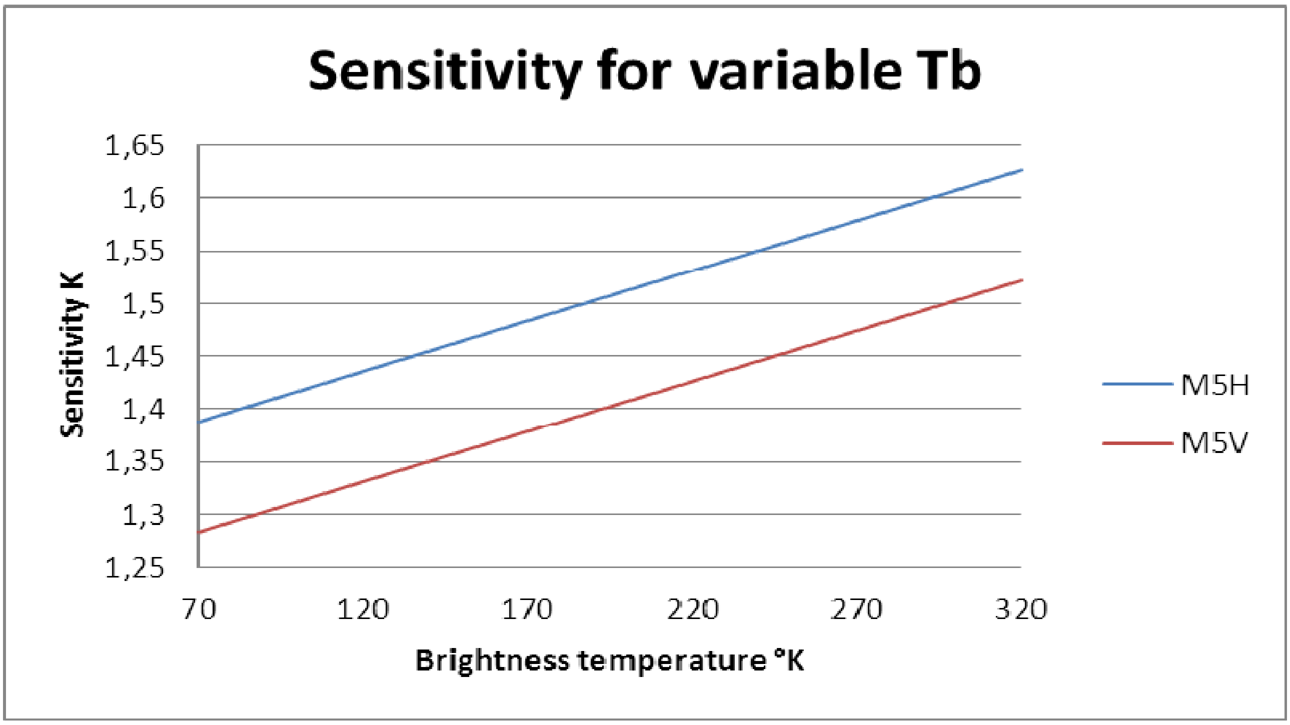
This estimation is based on the result given in §5.4 for orbit 738.

Receivers temperatures are firstly computed

Channel	M1H	M1V	M2V	M3H	M3V	M4H	M4V	M5H	M5V
Trec in K	312	416	644	915	923	535	497	1386	1276
NF	2,1	2,5	3,2	4,2	4,2	2,9	2,7	5,8	5,5

The estimation of the radiometric sensitivity is then realized with the theoretical formula for brightness temperature varying in the range [70K,320K] which is the range seen on the Science data.





These results show clearly that the science data with a low brightness temperature (sea, ice,..) are observed with a better sensitivity.

Lower is the receiver temperature of a channel, better is the gain in radiometric sensitivity for the low brightness temperature.

6. CONCLUSION

All the radiometric sensitivities of MARFEQ are well within the requirements after 15 months of operation.

Up to now the performances are better than the goal design.

The "in flight" radiometric performances are better than the last "on ground" performances measured.

Today, no significant degradation on performances has been seen on MARFEQ (RF subsystems of MADRAS)