# ERROR BUDGETING FOR RADIOMETER THERMAL VACUUM TEST


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Abstract: A new generation of microwave radiometers is being designed at this time [http://npoess.noaa.gov/mis_TXT.php]. Verifying the performance of space-borne microwave radiometers in a post-integration series of tests in a thermal vacuum chamber is a standard, but key pre-launch event [Jarosik, et al., 2003; Saunders, et al., 1995]. The actual quantities of interest are, of course, those describing the on-orbit operation of the sensor. Post-integration testing of the system in a thermal vacuum (TVac) chamber, supported by careful error analysis, is the best available technique to ensure that the flight performance limits can be met during post-launch operation. However, not all errors that determine on-orbit performance can be measured in TVac, and those that can be measured may have different appropriate levels in testing from those expected on orbit. The proper subset of errors that are amenable to performance verification in TVac must be determined, followed by a translation of the on-orbit levels of these errors to those appropriate from TVac measurements. An error budget for the TVac test set up must be constructed to ensure that the measurements can be made with the necessary level of fidelity.

Properly and precisely defining the errors of interest provides the underpinnings of this effort. A sensor error budget will have a subset of applicable errors when compared to a system error budget that must include the effects of the platform. It is also important to specify the data processing level and the assumptions on which the budgeting is based, to prevent confusion regarding the inclusion of particular error terms, whether as residual errors after the application of corrections, or as full-blown, uncorrected errors in the budget. The confidence level of the overall error is typically straight-forward, but the accounting of contributing errors must indicate

whether each of these is defined at the one-sigma level, the three-sigma level, or the not-to-exceed level. Different errors can also be treated at different confidence levels. Related to this is the question of whether the budgeting is done at the "worst case" or nominal value level.

The TVac environment is far from a perfect simulation of the satellite operational environment, and the sensor may not be in a completely flight-like condition. For instance, in place of a cold sky (2.7K) calibration point from a reflector, a pyramidal calibration target cooled by liquid nitrogen is used. Not only will this calibration point be at a higher temperature (around 80K), but the errors on this calibration effective temperature will be different. Cold sky reflector sidelobe contamination and finite emissivity will be replaced with feedhorn to target coupling and measurement errors on the physical temperature of the radiating surface of the target. Beam efficiency of the main beam and finite emissivity of the main reflector also cannot be checked in TVac. The error budget for the test set up must account for these new errors and ensure that they are held to a level that is consistent with the accuracy and precision of the needed measurements.

This work will start with an error definition that will serve as a context by which the TVac results may be used to infer on-orbit operation. This definition will then guide the rest of the work. A general sensor description will be used to define a collection of errors that will determine the calibration accuracy and stability of the system. These errors will be parsed into those that can be verified in TVac (even if only as a "rolled-up" combination, rather than as individual errors) and those that must be verified through other tests and supporting analysis. For the terms that are applicable for Tvac, the confidence level of each will be defined and justified. Transformation from an on-orbit or other appropriate error level specification to the level that must be met in Tvac will be performed. A description of a typical TVac test setup, along with testing to be performed will be given. An error budget for the setup will be determined using the fidelity level that was arrived at during the transformation from the sensor spec.

References

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