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LIGHTNING IMPACT REPORT

B. CROSSE, M. JOHNSTON-HOLLITT, D. EMRICH, A. MCPHAIL. JUNE 2019

Curtin University

1. EXECUTIVE SUMMARY

In December 2018 the MWA Board asked how many LNAs the MWA replaced annually and what was the impact of lighting on the array. This report provides a summary of the impact of lighting on the array over the period since operations commenced. The number of LNAs replaced annually is not associated with the frequency of lightning strikes but rather a function of electronic degradation. At present we replace ~100 LNAs per annum. Tracking of MWA components at this level of detail is difficult at present as we do not have the budget to cover professional component management software. We have undertaken an investigation on how to improve the situation, but it is reliant on further in-kind provisions by Curtin.

2. LIGHTNING IMPACT

MWA has suffered approximately five serious lightning events since operations commenced in 2012 that have resulted in moderate, but mostly repairable damage to the instrument. In each case, several things appear to happen simultaneously.

1. Some mains circuit breakers supplying the receivers are tripped due simply to current surges. This removes power from the affected receivers, and until the breakers are reset, means that the associated sets of eight antenna tiles are not accessible in any way. This also means we cannot determine if any individual tiles have failed until the receiver is alive again.

2. Mains supply circuit breakers are tripped due to an internal power board shunting surges, and “failing short” due to internal components failing. This condition is NOT reset when the breakers are cycled, requiring the internal power board to be replaced before the breaker will reset. Again, until this condition is remedied, the associated eight antenna tiles are not accessible and we cannot determine if individual antenna tiles have failed until the receiver is restored.

3. Once the receives have been restored, we have found that some number, typically between 30 and 45 antenna tiles, fail in one of two main ways, as a result of a circuit board failure in either the associated receiver slot, or the associated beam-former, or both. In every case, the affected tiles do not respond to “pointing” commands. Of these some remain pointing to the zenith and continue to pass RF signal, while others are “flat-line”, that is, supply no RF signal at all.

Failures are detectable within seconds of occurrence, due to a status web-page visible anywhere in the world. However, tripped circuit breakers require a person on site to recycle them, which in turn means that any further damage “masked” by downed receivers cannot be determined at a minimum until the next working day after the event.

The failed power boards have been stripped, and it has been determined that in every case, Metal-Oxide Varistors (surge suppression devices) have failed short, and physically disintegrated, protecting any attached devices from further damage, but, as noted above, preventing the circuit breakers from being recycled until the damaged power board has been replaced. These power boards are moderately cheap, fail relatively infrequently, and are easily replaced, so we do not believe it is worth taking measures to reduce their rate of failure.

However the time, effort and cost to repair and replace the circuit cards in the receiver and beam-former slots warrants some consideration as to mitigation methods that might reduce the number of overall failures. In most cases there is no visible sign of damage, but lab diagnosis points to a small number of analog semiconductor components which fail. While the components themselves are of the order of a dollar or so in value, and are easily replaced, the associated cost of site visits and nuisance value of many cover screws required to access the cards in the field justifies some expense if it reduces the rate of failure.

With this in mind, we have trialled two types of F-type in-line, external lightning arrestors available commercially. Four units of each type were fitted, two at the receiver end and two at the tile end of the Data-over-Coax cables, external to the enclosures that require many screws to access. We realise this is not a statistical test, however one type has already failed to prevent damage to the associated tile, while the other (more expensive) has prevented damage so far.

The second advantage of the more expensive unit, is that it has a higher surge current rating and the actual discharge/arrestor device is testable and replaceable without removing the lightning arrestor from the cables.

Datasheet specifications, and early analysis indications show that there is no discernible effect on the RF signal quality after the lightning arrestors are installed.

With all the foregoing in mind, and with the understanding that these are still not a guaranteed method of mitigating the effects of lightning, but that even a moderate reduction in damage is advantageous, it is proposed that we purchase sufficient units of the modular lightning arrestors (estimated to USD$12,200 as at 18-Mar-2015) to fit out all 128 tiles and then further revisit the issue in the future.

Apart from potentially protecting the MWA telescope from further damage, or at least reducing the severity, lessons learned will inform future large-N telescope designs with surface laid cables over distributed areas.

3. LOW NOISE AMPLIFIER REPLACEMENT

Replacement of Low Noise Amplifiers (LNAs) is primarily the result of electronic component failure. The primary cause of LNA failure is acidic soil etching off the components after rain or moisture. Tracking the number of LNAs replaced in more detail is difficult as the MWA does not presently have a professional level component inventory. Estimates of the replacement of LNAs over the years of operation suggests that ~100 LNAs are replaced annually, and the failures are distributed over the year.

4. MWA COMPONENT MANAGEMENT SYSTEM

In Q1 and Q2 we initiated a project with the Curtin University School of Business Management for final year students to undertake a project to investigate a suitable component inventory management software system for the MWA. The findings of that work, present to the MWA Director and Field Coordinator in June 2019 suggests a potential solution. Via consideration of a suitability matrix, developed in consultations with the MWA Operations Team, the choice of possible software solutions was limited to two commercial products: QFM and Freshservice. QFM is too expensive to be adopted by the MWA directly, however, it is currently under consideration for University-wide adoption by Curtin, which would provide MWA access. If Curtin provides this option, MWA will adopt this to track components going forward. This again highlight the reliance of MWA on Curtin to provide service above and beyond those needed as part of their role as MWA Lead Organisation, and the need for the Board to appreciate the limitations of the MWA Operations to undertake detail component use analysis given the extremely tight operations budget.