final critical factor is in deciding how these states are determined and applied. The graph shown in Figure 18 details how this is done for carbon thickness.

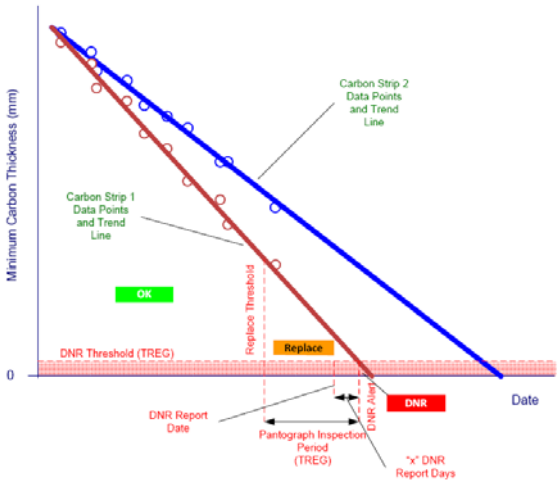

Figure 18: Carbon maintenance statuses

13.3 System and Infrastructure Maintenance

Real time monitoring of PCMS equipment health also has an impact on the system's design and a significant multi-disciplined business integration component.

The communication of the real time system health alarms to the systems maintainers is undertaken via an Infrastructure Condition Operation team. This required the integration of the PCMS with an existing system used by the latter group and involved software development and the modification of the electrical cabinet on site.

This integration also required changes to an existing Fault Management System used by Sydney Trains.

The role of this internal system is to standardise the communication of systems' faults and notify the maintainers and affected parties. This system also allows for keeping track of fault status and the corrective actions undertaken to address these.

Specific training on the PCMS maintenance and fault management procedures has to be delivered to both Infrastructure Control and Systems Maintainers.

The PCMS infrastructure is maintained by a number of groups within Sydney Trains. This requires a clear definition of maintenance boundaries and capturing all the new assets in the relevant Asset Management systems.

Special safety rules need to be applied during the maintenance of the overhead wires and contact wire registrations at the PCMS sites due to Class 4 lasers used by these systems.

The safety requirements related to the Class 4 lasers include: new procedures and briefings for the maintenance staff; modification of the electrical PCMS cabinet to include a lockable external isolating switch. The latter will allow maintainers to isolate the system on site during emergency infrastructure maintenance works where Class 4 lasers pose a risk to the workers.

14. CONCLUSION

Since 2013 Sydney Trains has been working tirelessly to trial and subsequently roll out network wide a Pantograph Condition Monitoring System that meets the expectations and requirements of the business. Due to this work Sydney Trains' PCMS are now thoroughly understood, deliver highly reliable data, are integrated in the business and have an improved level of confidence from the user community. The system has proven that it can prevent incidents and deliver the benefits it is designed for. Moving forward Sydney Trains will work to ensure that the data is also utilised for realising the expected maintenance and material savings benefits.

Our experience with the PantoInspect PCMS is that it is an advanced and innovative market leading technology that will continue to improve with the input of its users. Without such a system Sydney Trains would struggle to reduce dewirement incidents, improve maintenance practices and reduce time out of service for critical rolling stock assets.

15. ACKNOWLEDGEMENTS

The authors of this paper would like to express their thanks to:

- PantoInspect personnel for the development and manufacturing of PCMS referred to in this document and for all the technical information made available to support this paper.
- Australian Rail Technology Projects personnel who have supported and contributed to the integration, testing and delivery of the PCMS project and this paper.
- Sydney Trains' personnel for the support to this paper and the contribution to the delivery of the PCMS project.

16. REFERENCES

1. Parson Brinckerhoff, 2011. RailCorp Condition Monitoring Strategy 2012 - 2017, Sydney.