

Panel 3

1	Good afternoon. I will describe some experience we have gained in monitoring GICs and their effects. In this work we have collaborated continuously with the entity presently known as SANSA Space Science. I also acknowledge intermittent collaboration with Eskom and recently the contribution of NamPower, the utility in Namibia.
2	The first topic given to the panel is present monitoring. Again, you have the details in the agenda.
3	My introduction to GICs was an invitation from Eskom to participate in the EPRI Sunburst project. In a comparison of measurements and calculations, the agreement was good but not perfect. This started a search for the differences.
4	We found the non-uniformity of assumed uniform fields made a difference to the calculations. SANSA is implementing denser measurements to obtain better models of non-uniform fields. As an indication of scale, the distance between the Intermagnet observatories of Tsumeb in the north and Hermanus in the south is about 1000 miles.
5	We are also measuring GICs in a terminal substation by direct measurement in the neutral and using differential magnetometer measurement of the GIC in single circuit overhead lines. Eskom also measures approximate GICs in about 20 transformers.
6	Analysis of the DGA records of over 200 large transformers, mostly GSUs, led to the Low Energy Degradation Triangle. Healthy transformers locate in the bottom left corner. Degradation progresses upwards and right. Jumps in the degradation trajectory correlate well with GIC events as well as with other factors.
7	The second topic is the potential for more monitoring.
8	A characteristic of extreme GMD events is the correlation between magnitude and duration. It appears that severe events are associated with multiple CMEs from the Sun. The well-known Carrington event was not the result of a single CME. By comparison, a much smaller event in 2004 lasted only 3 days.
9	In an analysis by the UK Met office, at least 5 shocks are discernible in measurements at ACE during this event. Such relationships in extreme GMD events justify further study and modelling. The analysis also illustrates the potential benefit of having co-located simultaneous data ...
10	... such as of solar wind and Earth surface fields, and GICs and field measurements. Better understanding of system response requires non-active power, power, voltage and current measurements, including GIC. We have found good reasons for field and electrical parameter measurements to be made at 10-second cadence. And transformer degradation studies require access to DGA and failure records.
11	Assessing the impact of GIC events requires a context of normal system faults. As described earlier, public benefit and mitigation depend on the V@R. The collection of characteristic failure and cost of interruption data is essential to assess public benefit.
12	Research does not require real-time data. Data collection for operations

	imposes additional requirements well understood by utilities.
13	Deterministic system modelling is extremely limiting. Probabilistic data models and analysis techniques reflecting real dispersion are needed – from the GMD to the costs of interruptions. Balancing public benefit requires more than simplified deterministic estimates of cost of impact and avoidance.
14	Finally, the topic of the availability of data
15	Our analysis of large transformer failures at Eskom shows a strong increase after periods of large GMDs. A similar response is apparent in the PES survey of GSU failures in the USA between 1980 and 1994. Cigré surveys provide failure rates but not time profiles.
16	Although I can find many failure reports on the web, and Cigré showed average annual failure rates of 1% for large transformers, my experience is that most utilities will not allow access to GIC or DGA data, claiming it is sensitive.
17	Utilities collect some relevant data, but most do not analyse it, nor allow others to see it. And most resist suggestions that ideas from outside could have much value. As a result, space weather research appears to be more advanced than GIC and public benefit research.