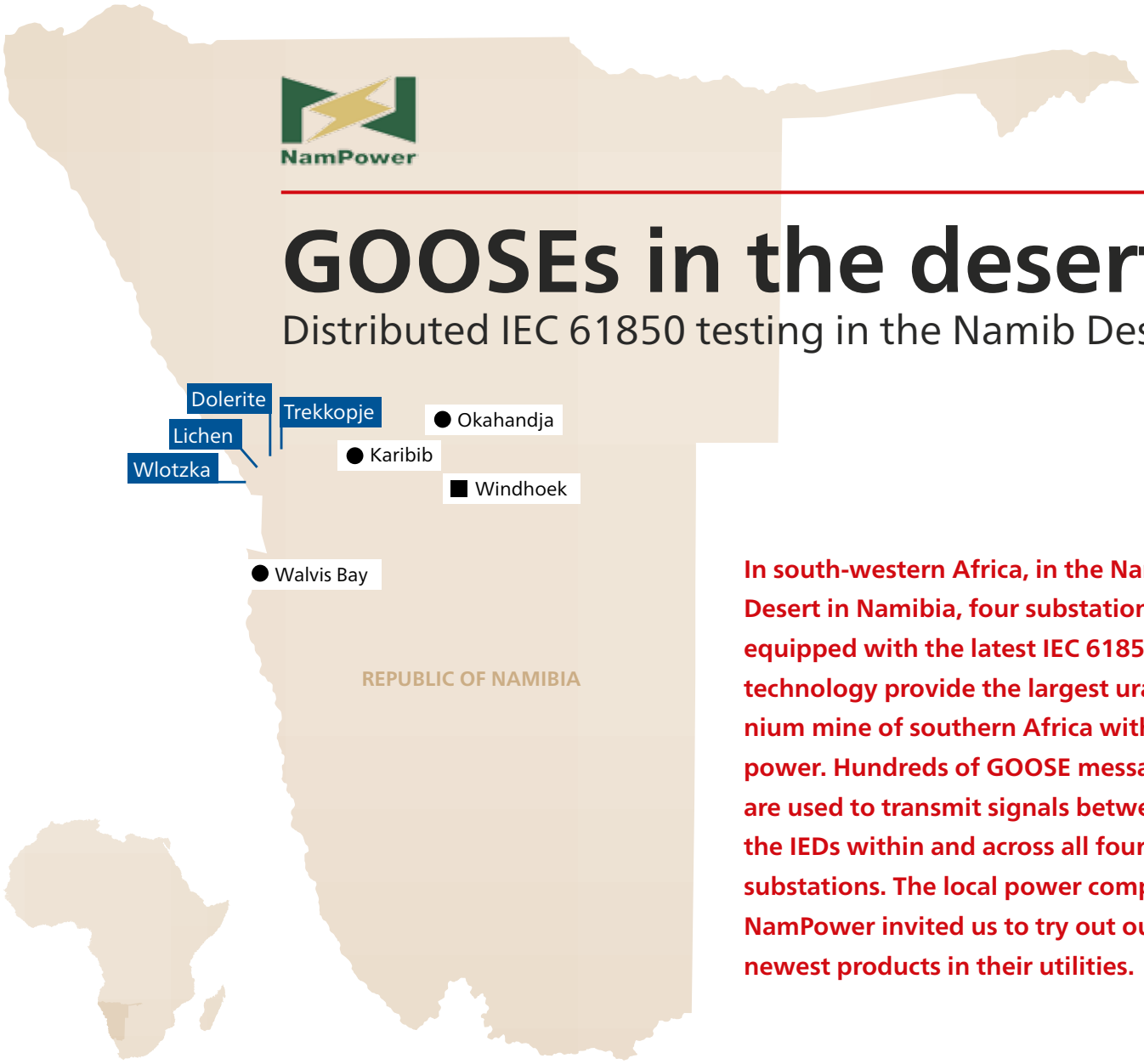

GOOSEs in the desert

Distributed IEC 61850 testing in the Namib Desert

In south-western Africa, in the Namib Desert in Namibia, four substations equipped with the latest IEC 61850 technology provide the largest uranium mine of southern Africa with power. Hundreds of GOOSE messages are used to transmit signals between the IEDs within and across all four substations. The local power company NamPower invited us to try out our newest products in their utilities.

The substations are located between a desalination plant at the west coast of Namibia and the Trekkopje uranium mine, located approximately 65 km north-east of Swakopmund. An optical ground wire connection between the four substation automation networks makes it possible to exchange link-layer protocol messages like GOOSE between all locations.

Verifying SCL against the network

Upon arrival at the first substation at the coast, we used the DANEO to verify if the GOOSEs transmitted on the substation network matched the configuration in the Substation Configuration Description (SCD) file. We configured the network switch to forward all GOOSE packets to the DANEO and within a few seconds all GOOSE ▸

«I wish the DANEO was available when we built these substations. It would have saved us many hours of troubleshooting interoperability and signaling problems.»

Chris Viljoen
Senior Engineer: Protection, NamPower

messages present on the network were analyzed by the DANEO. As shown in Figure 1, we found out that one of the 104 GOOSEs on the wire did not match the configuration in the SCD file: The VLAN ID was incorrect. Depending on the configuration of the network switch, this could prevent the subscribing IEDs from receiving the messages. We also saw that 40 GOOSEs that were specified in the SCD file, were not present on the network. These were from IEDs simulated during commissioning, these are not needed anymore during operation.

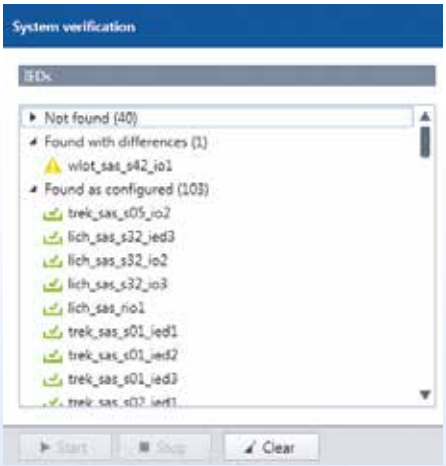

Figure 1: Result of verification against SCD file

We also used the new IEDScout 4 to check if the MMS reports sent by the IEDs match the definition in the SCD file. While doing this, one thing caught our attention: A certain Data Attribute changed its value in short intervals, flashing yellow in the IEDScout Activity Monitor. It was an attribute for signaling an alarm condition on a Remote Terminal Unit (RTU). We tracked it down to a defective fiber optic cable, which was immediately replaced.

Going distributed

After some more local measurements with one DANEO, we started setting up the distributed measurement between multiple substations. For this, static IP addresses were assigned and network switches were configured to allow access to the network. Additionally, we placed an OTMC 100p GPS clock on the roof of the building to obtain Precision Time Synchronization (PTP) in the sub-microsecond range for our measurement. We also wired an ISIO 200 to provide a GOOSE signal which could be manipulated remotely for testing purposes

without interfering with the live substation. We connected the ISIO 200 to a binary output of an RTU.

We left the DANEO, ISIO and OTMC there, running over the night. In the next morning we drove directly to the second substation, confident that all our devices will be accessible remotely.

At our new location we set up another time-synchronized DANEO to measure the time it takes until a binary signal change at the ISIO in the first substation is transmitted to our new location at the second substation. Basically we measured how long it takes until the same GOOSE packet arrives at the next substation 20 km away. Figure 2 shows that the propagation delay between the two substations was only 149 µs for that particular measurement.

Figure 2: Top to bottom: binary input change and GOOSE at substation 1, GOOSE and binary output change at substation 2

Figure 3: Histogram of propagation delay over (longer) redundant path

Measuring the worst case

This measurement represents only one sample, but it doesn't give us any hint on how the worst case could look like. So we decided to do a propagation delay measurement with the DANEOs, where hundreds of samples are collected to create a histogram. To get more interesting results, we dared to unplug one of the redundant connections, forcing the GOOSEs to travel all the way to Trekkopje before they reach their destination – a round trip of approximately 75 km. Figure 3 shows that most of the measurements were around 476 µs, but there was one outlier observed with a delay of 658 µs.

NamPower

NamPower, Namibia's national power utility, was born out of the South West Africa Water and Electricity Corporation (SWAWEK). In July 1996, SWAWEK became NamPower and now it is a main driver of Vision 2030, Namibia's blueprint for broad-based, sustainable economic growth. NamPower's core business is the generation, transmission and energy trading with almost 4.4 GWh units into system in 2014. The 'pulse' of Namibia's national power utility beats directly from the National Control Centre, situated in Windhoek. More than 950 dedicated employees and management are working together on all aspects of socio-economic development.