WHITE PAPER

Business Benefits of Automating the Commissioning of Submarine Network Services

Business value provided by intelligent, data-driven automation of network services

Cost, quality, and Time To Market (TTM) are the main metrics for successful network service delivery. Cost, in terms of engineering effort, is best judged by customer expectations being met quickly and efficiently, resulting in reduced site visits and network performance at or above paper-based expectations. Automation in service delivery is proven to provide cost reductions and quality improvements, correlating with increased customer satisfaction and network performance at Beginning of Life (BoL). TTM provides a competitive differentiator for operators turning-up services for internal and external use.

In an automated Submarine Line Terminal Equipment (SLTE) turn-up service, cost benefits are realized through faster deployment times—moving from days to hours—as well as lean deployment options that simplify operations. The intelligent, data-driven automation platform also reduces the need for high levels of on-site expertise and allows for a smaller Network Operations Center (NOC) footprint to sustainably support operations while eliminating human errors for better consistency of service turn-up and improved market differentiation.

The improved quality of automated SLTE turn-up is evident through capacity gains due to higher spectral efficiency and optimal line rates based on real-time analysis of line-system performance. The quality will only continue to increase as more relevant data is made readily available from the modems and line system as product innovation brings further advances in telemetry and streaming data.

Quality improvements and cost reductions can be achieved by evaluating the five applications below, executed by intelligent, data-driven automation during a submarine network field deployment.

1. Automated transmit (Tx) and receive (Rx) Optical Signal-to-Noise Ratio (OSNR) measurements from Optical Spectrum Analyzer (OSA) trace data
2. Optical power hunt to evaluate ideal per-channel launch power
3. Electronic chromatic dispersion compensation optimization
4. Automated characterization of system bandwidth using a minimum modem fill to optimize capacity and channel plan
5. Automated collection of modem parameters using a configurable polling interval and duration

Automated Tx and Rx OSNR measurements from OSA trace data

One of the measurements of bidirectional performance data is the Tx and Rx OSNR. This is calculated on different channel plans during initial line-system characterization to provide performance expectations and recalculated on the final plan post deployment to provide baseline system performance data.

A traditional manual approach to OSNR measurement would be to use an OSA to measure the integrated power of the channel over its width (P1), blank the channel and measure the integrated power over the same width giving the noise power (P2), and calculate the reference power over 12.5 GHz on the channel central frequency (P3). OSNR is then calculated by the equation below:

$$OSNR = 10Log\left(\frac{(\mathrm{P1}-\mathrm{P2})}{\mathrm{P3}}\right)$$

This is a time-consuming process which field data shows takes approximately 15 minutes per channel.

The case for automation is clear in this instance, with software not only increasing efficiency but also increasing accuracy. Task automation software takes around one minute to calculate with either an offline or networked Optical Spectrum Analyzer (OSA), with a time savings of 93 percent. Software automation also leverages statistical methods such as linear regression and approximation on a real-time basis to improve the accuracy of the OSNR calculation.

One such example of this is Spectral Hole Burning (SHB) compensation. SHB compensation, or localized gain correction, has been found to be necessary for accurate results when using channel blanking and calculating OSNR[1]. It was found that blanking a channel artificially raised the noise floor, which therefore needed to be accounted for in the OSNR calculation algorithm to provide accurate results for later use. This is a sound example of how having a tool distributed to engineers can allow rapid global updates to procedure as innovation continues driving forward.

Optical power hunt to evaluate ideal per-channel launch power

The ideal launch power of a channel is that which gives the least non-linearity in the system. This is discovered through an activity known as a power hunt. The process of manually determining optical launch power involves an engineer using an OSA for each channel and each proposed launch power to capture the OSA spectrum, channel performance data, Q factor, and channel power scaled to the Total Output Power (TOP) of the fiber pair. This entire process is repetitive, time consuming, and error prone.

By utilizing software control, human errors from recording the data and performing calculations are eliminated, and operator fatigue is reduced by eliminating repetition. Time savings are also evident; for example, modem configuration changes and captures can run in parallel, rather than as a serial exercise.

Electronic chromatic dispersion compensation optimization

Electronic dispersion compensation applied to modems, depending on the modem type, can have input ranges of circa 450,000 ps/nm values. Manually sweeping the values to find the best performance measured by the Q factor is—like a power hunt—repetitive, time consuming, and error prone. An engineer must apply the desired compensation value to each modem, wait for it to take effect, measure, and finally record performance impacts.

Software control removes human error in data processing and recording, as well as reduces operator fatigue. While the pre-dispersion compensation updating operations must be carried out in serial on the modem—meaning that there is not one large increase in time savings—the small savings in recording and editing time add up to produce significant overall savings.

Automated characterization of system bandwidth using minimum modem fill to optimize capacity and channel plan

While offline planning tools and algorithms can provide optimal channel plans, it can be a time-consuming process in terms of capacity and spectral efficiency. It often involves test equipment in addition to the SLTE hardware. Automating this process during deployment can provide a 50 percent reduction in effort as well as time savings, moving from days to hours.

Automated submarine cable spectrum capacity optimization has been shown to expedite field deployment time[2], reduce the deployment footprint and expertise requirement, and, during cable characterization, provide accurate capacity forecasts for spectrum-sharing applications—all while leveraging real-time optical data.

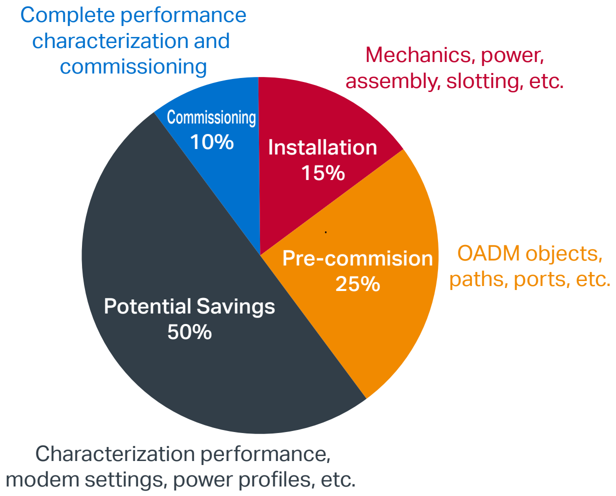

Figure 1. Potential savings of automated characterization

The spectrum optimizer component of the Ciena Services SLTE automation software breaks down the optimization cycle into four phases:

1. Initialization
2. Characterization
3. Optimization
4. Verification

The initialization phase consists of connecting to the SLTE platforms' shelves and checking parameters such as the inventories and minimal operational requirements (three bi-directional channels).

The characterization phase either works as a sweep or in full-fill mode. It can also optionally include a power hunt, which is preferable for compensated cable systems in contrast to flat launch power preferred on D+ cable systems for capacity prediction. A sweep uses a reduced number of modems to step across the targeted region of the spectrum and take measurements, whereas full-fill mode takes measurements based on the current modems and their center frequencies.

In sweep mode, depending on the SLTE system type, Amplified Spontaneous Emission (ASE) noise is carefully reset, and the initial channel objects built. The modems are then set to the probing line rate specified by the user and the initial sweep from the blue edge to the red edge begins in the near-to-far and far-to-near directions. For each center frequency probed at the probe line rate, the Effective Signal-to-Noise Ratio (ESNR), Tx and Rx power, average power into Fiber (pFIB), and Generalized Signal-to-Noise Ratio (GSNR) are recorded to allow for capacity prediction[3]. The ESNR versus frequency plot is also displayed in graphical format, updating as new measurements are available.

Alternatively, in full-fill mode, the modems are set to the probing line rate specified by the user, and the ESNR, Tx and Rx power, pFIB, and GSNR are recorded and displayed in the same fashion as a sweep.

Once the characterization data from the system has been acquired, the optimization phase begins. Each direction is analyzed independently to find the optimal line rates, and the expected ESNR values are calculated. The two directions are then reconciled using polynomial curve fitting to ensure bilateral stability and congruence. The data is then provided to the user as channel plan plots with expected ESNR values.

The final stage of verification is essentially repeating the characterization stage, or sweep. However, instead of using the probe line rates, the previously generated optimal channel plan is used. The final step empirically validates the plan and confirms the channel stability.

The total run time of the spectrum optimizer component depends on the characterization mode—sweep or full-fill—and, if using sweep mode, the number of modem pairs available. For a channel plan of 43 channels using six modem pairs, the full sweep from initialization to verification is consistently shown to be approximately five hours, and a full-fill scenario is around three hours. In comparison, a manual sweep would take around three days

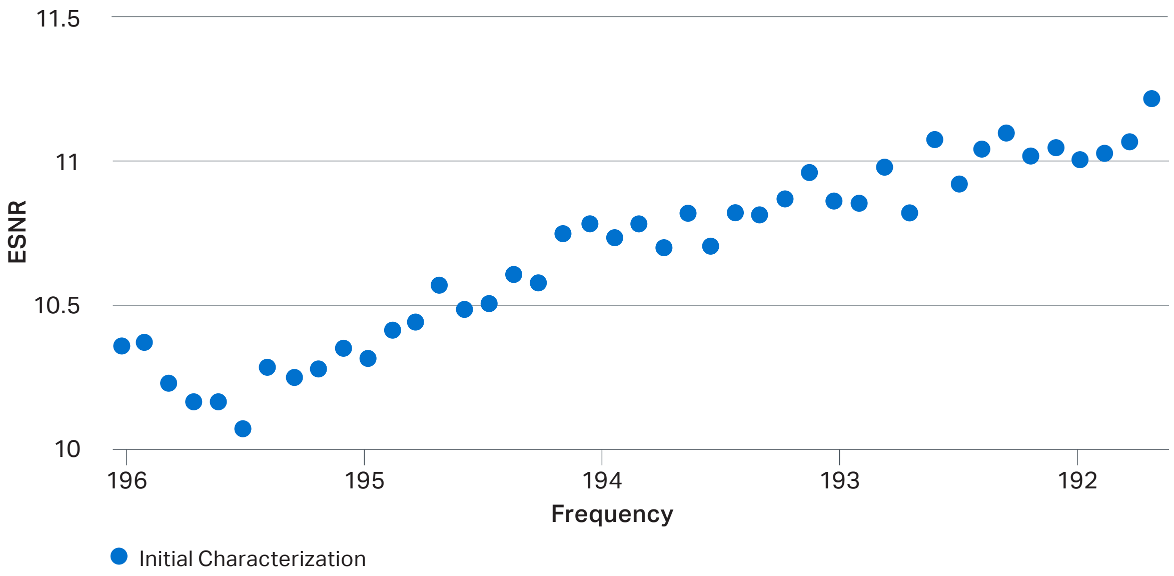

Figure 2. Effective Signal-to-Noise Ratio (ESNR) vs frequency

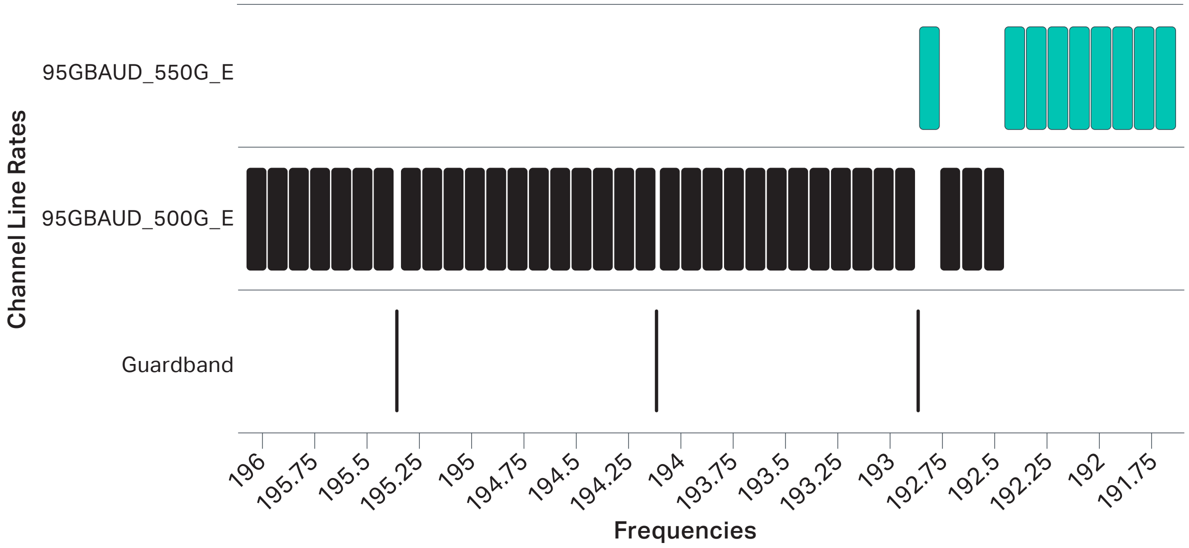

Figure 3. Example optimized channel plan applicable for both directions

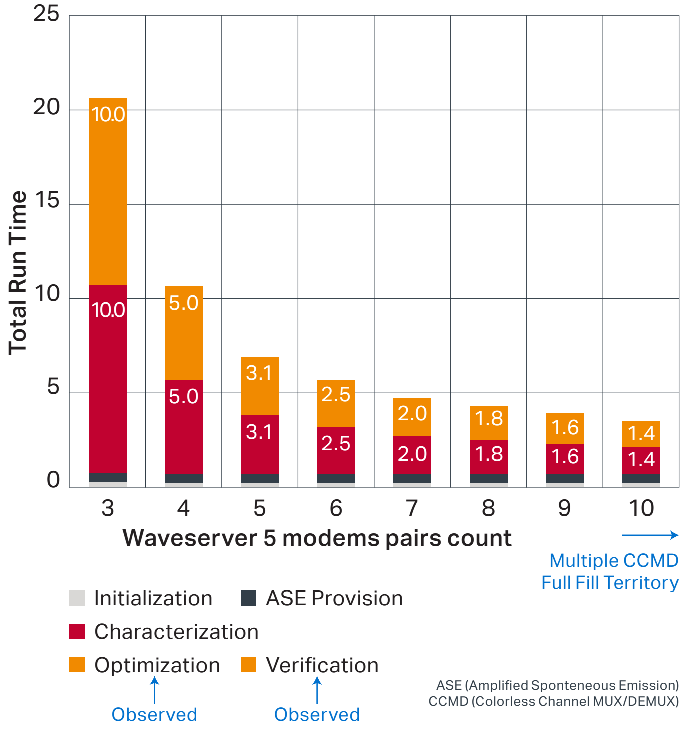

Figure 4. Optimizer estimated runtime vs. number of modem count (44 channels, 100 percent characterization and verification, no skip)

Once the process is broken down, the benefits of automation are fully realized. Automation reduces engineering effort—both on site and in the planning departments—and reduces on-site costs in terms of test equipment and engineering expertise. Automation also provides better results via a verified and optimized plan that accounts for capacity and spectral efficiency and is ready for deployment by using the network as a sensor.

Automated collection of modem parameters using a configurable polling interval and duration

During in-station and segment testing, confidence trials are required for a defined period where all client ports must run error free. Due to the length of confidence trials, it is not feasible nor desired to wait until the end to check for error conditions or take corrective action. As such, periodic monitoring of the tests and modem states is required, which is not feasible for an operator to manually capture due to the number of test channels and duration of tests.

By leveraging software to monitor all test points or channels, the effort of the exercise is reduced and the speed at which issues can be detected, and therefore resolved, is greatly enhanced. Further, the ability to generate test reports from the collected data greatly reduces the effort required to produce reports for the customer handover. Figure 6 captures data come from Ciena Services SLTE automation software.

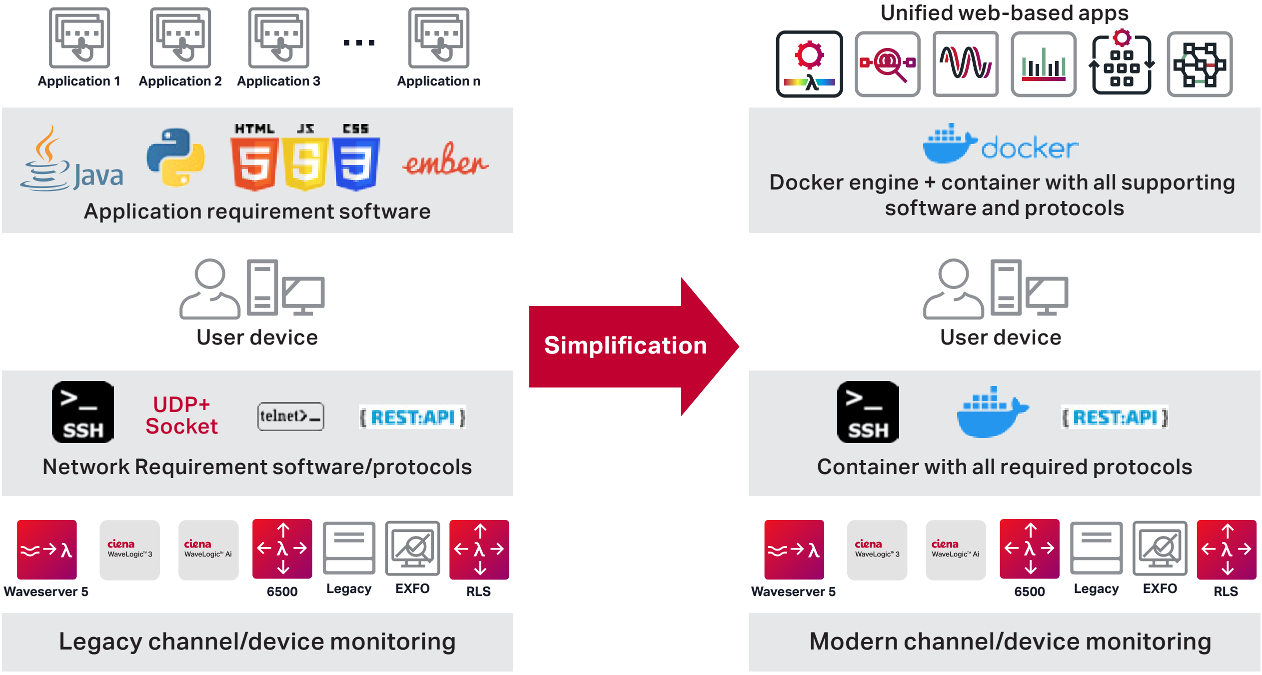

Figure 5. Data collection and application simplification

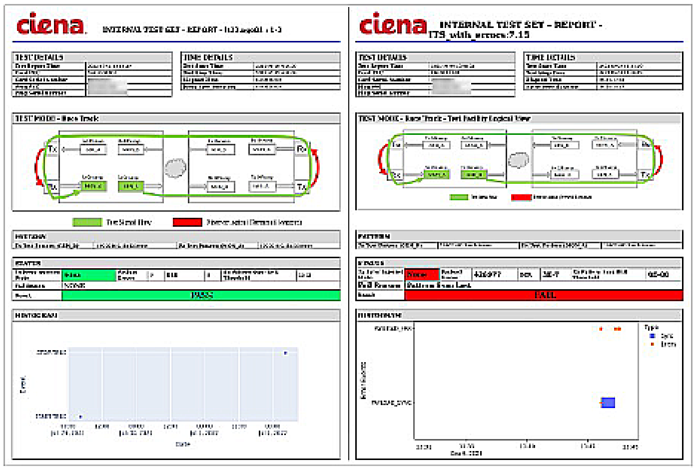

Figure 6. Automated Bit Error Ration (BER) test results

Intelligent, data-driven automation provides significant business value

Even from looking at only five distinct areas of automation within an SLTE deployment, the benefits are appreciable. Quality, accuracy, and efficiency are all enhanced through continued investment in automation. The increases in quality and accuracy are perhaps best quantified though the consistency that comes with automation. Complex and repetitive tasks, where there is higher risk of human error, will time again produce consistent results due to removing the source of the errors.

Time savings speak for themselves and show the efficiency gains to be made in terms of engineering hours. But efficiency gains are not just measured in time—there are gains in operational efficiency through reallocating where different engineering skillsets are required. By bringing in more remote software capabilities, higher-skilled engineers have more scope for more projects and better use of their time.

Any task can be completed by a human, given enough time and knowledge. However, the loss of efficiency and risks to accuracy are substantial, especially for complex and long-running tasks. From service delivery beginning as a fully manual process to slowly gaining efficiency as standalone single-task applications were developed ad hoc, to then amalgamating and containerizing these into a central, unified, and intelligent tool suite, the playing field has been significantly changed. This is especially important now, as the industry moves toward ever-increasing complexities—such as multiple baud rates to harvest the best performance from cable systems. Additionally, continual development of modems and line systems as sensors, and providing programmatic interfaces to this real-time data, only strengthen and encourage the case for continued investment in automation.

? Was this content useful? Yes No

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