Phonak
Insight.

Reliability Redefined: Using artificial intelligence to let HCPs focus on what matters

We are transforming hearing aid reliability by using artificial intelligence. Through innovative system screening we determine reliability indicators in real-time. This proactive approach allows us to continuously improve hearing instrument reliability, reducing service interruptions for our customers and allowing Hearing Care Professionals (HCPs) to focus more on client care.

Jagoda, L., Ignasiak, N., Seel, I., Schubert, F., Thielen, A. October 2024.

Key highlights

- Real-time system monitoring reveals insights into the operational health of our devices and empowers us to continuously improve product reliability
- Utilizing artificial intelligence we can predict and prevent potential service needs in the market

Considerations for practice

- Reliability indicators enable a proactive issue resolution reducing service cases and service-related drop-ins
- A reduction in repairs in clinc can free-up time for HCPs to spend on other tasks

Making Reliability the Foundation of Our Commitment

For people with hearing loss, the reliability of their hearing aids is an essential concern. Unexpected device failures pose a risk to their safety and ability to connect with the world. Reliability ensures consistent audiological support, enhancing quality of life by improving communication and social interaction without interruptions. Furthermore, the reliability of Phonak products is of great significance to HCPs, as it greatly affects their everyday work. According to internal surveys, HCPs spend between 20-40% of their time on service-related activities. Globally, this adds up to more than 10 million hours of HCP time spent on non-value-added activities. For HCPs, high product reliability reduces the frequency of device-related issues, allowing them to focus on client care rather than troubleshooting. It fosters confidence in the technology, ensuring that HCPs can recommend and fit hearing aids, with knowing they will perform as expected over time.

Self-diagnostics screening enables real-time identification and proactive resolution of issues from day one

Through systematic screening of the system's performance, we can continually enhance our products, promptly addressing and resolving any encountered issues to prevent recurrence. This proactive approach results in increasingly reliable hearing instruments that deliver a seamless experience, culminating in satisfied users and reduced service concerns for our customers. Consequently, the frequency of service cases decreases, enabling HCPs to concentrate on their primary responsibilities—counseling and engaging with clients.

Laying the groundwork: From device error reports to reliability indicators

To monitor system performance in the market, we have made a substantial investment in building the necessary infrastructure and tools. This extensive setup is essential before one can effectively start leveraging the gathered information. Each hearing aid logs error reports related to its operating state, such as bootups and shutdowns, as well as irregularities potentially indicating a need for troubleshooting. These reports provide valuable insights into the operational health of our devices. For these reports to be analyzed, they are transmitted to our database before they are structured and preprocessed, ensuring readiness for statistical evaluation. Throughout this process, we enforce robust security procedures to achieve data privacy, safeguarding all sensitive information (EU Medical Devices Regulation, 2017; HIPAA, 1996). By leveraging artificial intelligence on the aggregated data, we can identify issues for further investigation. This involves extracting features from the system's behavior and detecting patterns associated with service cases. Reports identified as indicators of reliability can then be proactively screened in the market from day one after product launch.

From theory to practice: Forecasting service needs by monitoring device reboots

A key indicator of software-related product stability is the frequency and number of unexpected device reboots. Our analysis of 400,000 Lumity devices over an eight-month period revealed that most devices operate seamlessly, running uninterrupted for an average of over 3 months—an outstanding result. However, through Poisson-probability simulations (Wackerly, D., Mendenhall, W., & Scheaffer, R. L. , 2007), we identified a small subset (~1%, see Figure 1) of devices with an unusually high reboot rate of more than once per week.

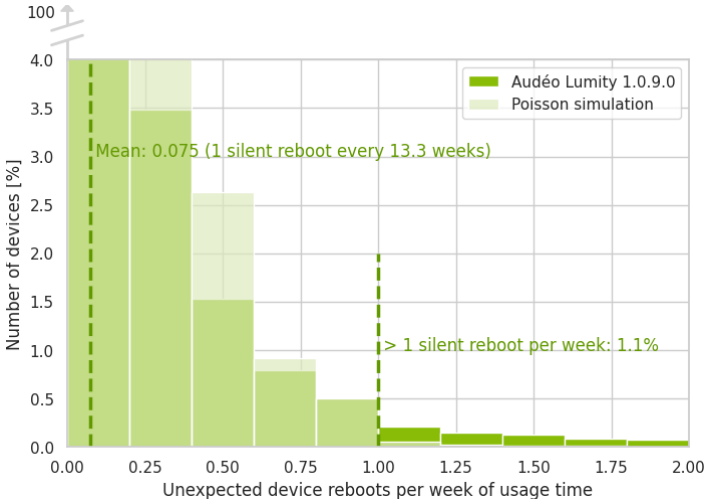

Figure 1. Poisson simulation and percentage of Audéo Lumity devices over frequency of unexpected reboots per week. This figure shows the percentage of a total of 400,000 Audéo Lumity devices across the number of unexpected reboots per week compared to the expected distribution based on Poisson-probability simulations.

We further examined the historical reboot rate of 5,000 devices sent in for service. By labeling devices with an unusually high reboot rate (>1/week) we calculated the probability of a device requiring service, based on its reboot rate. Finally, we found that these 1% of more frequently rebooting devices were more than twice as likely to require service. The derived probability function, combined with each device's reboot rate, now allows us to forecast the likelihood of an individual device requiring service. This enables us to proactively implement mitigation strategies, such as preparing for device replacements or firmware

updates, thereby supporting our customers to deal with service cases more efficiently, enhancing consumer satisfaction, and ultimately increasing our product reliability.

Screening low battery warnings to reduce service cases

The second most common category for hearing instrument service is battery related complaints. Using a similar approach as described above, we discovered that low battery state warnings exhibited an association with service cases. Our access to low battery warning events for both in-service and in-market devices enabled us to thoroughly investigate rechargeability-related service cases and identify this connection. To quantify the impact, we employed a logistic regression model to estimate the service-submission probability based on its number of low battery warnings (Gareth James, Daniela Witten, Trevor Hastie, Robert Tibshirani, 2013). Our analysis showed that more frequent low battery warnings increase the likelihood of a device needing service (see Figure 2). Around 9% of our previous service cases could be linked to this single reliability indicator.

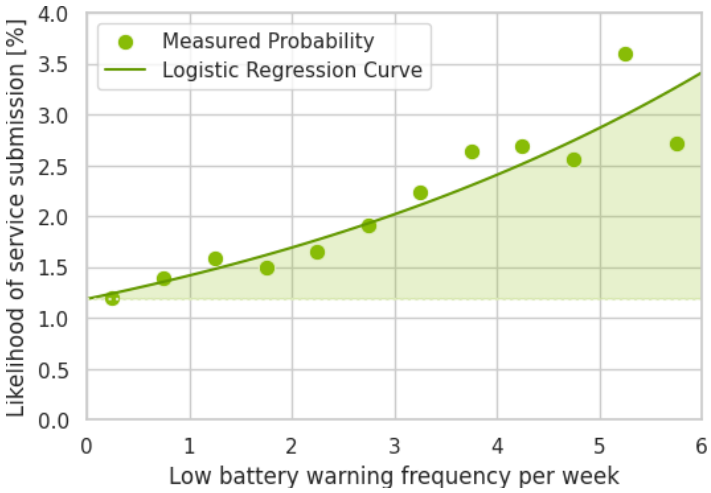

Figure 2. Likelihood of service submission over frequency of low battery warnings per week. The figure shows the relation between the frequency of low battery warnings per week (x-axis) and the probability that a device will be submitted for service (y-axis).

This observed relation motivated us to implement real-time monitoring of low battery warnings and battery degradation in the market. This gives us a head start, enabling immediate reaction to observed irregularities, informing us when to replace batteries and allowing us to start analyzing the root cause and working on a solution the same day. Typically, information about such issues would trickle in slowly, accumulating through service cases over weeks or months. We are now able to identify within days and to engineer a technical solution before the problem even arises as a service issue for our customers.

Future Horizons in Advancing Reliability

One significant advancement we are actively pursuing is the introduction of reliability indicators related to hardware and connectivity issues such as interruptions in smartphone connectivity or streaming. These indicators enhance our understanding of device reliability, complementing our existing focus on rechargeability and system performance. We envision future developments that could revolutionize reliability and hearing aid maintenance. For instance, HCPs could be automatically notified of potential service issues for their clients. Automated early notifications would enable HCPs to proactively contact clients for a check-up or resolve potential issues remotely, ensuring uninterrupted device performance. In this same future, clients could receive alerts through their app, empowering them to take immediate action. This functionality, already standard in consumer electronics, could naturally extend to hearing aids. In each of these cases, real-time trouble shooting and resolution will be a reality. By triggering system updates over the air, problems can be fixed as they are detected. This capability would significantly reduce the number of devices requiring service, enhancing the client experience, and freeing up valuable time for HCPs by reducing service-related drop-ins and troubleshooting appointments.

Conclusion

Reliability is a key element of Sonova's mission, ensuring seamless hearing aid performance and reducing service-related disruptions for our customers. Our advanced real-time system screening and predictive reliability indicators enable us to proactively address potential issues, minimizing the need for troubleshooting and service appointments. This allows HCPs to focus more on client care and less on device maintenance. As we continue to innovate, we aim to make real-time issue resolution a standard practice, further streamlining the overall efficiency of hearing aid maintenance. This commitment not only fosters trust in our technology but also ensures that HCPs can deliver the best possible care, while their patients enjoy the delight of hearing.

References

EU Medical Devices Regulation. (2017). EU Medical Devices Regulation (Regulation (EU)) 2017/745 of European Parliament and the Council of 5 April 2017 on medical devices) and 45 C.F.R. § 164.501 et seq.

Gareth James, Daniela Witten, Trevor Hastie, Robert Tibshirani. (2013). *An Introduction to Statistical Learning : with Applications in R.* New York: Springer.

HIPAA. (1996). United States' Health Insurance portability and Accountability Act of 1996, as amended, and its implementing regulations (collectively, "HIPAA") (see 45 CFR § 164.514(b)(2)).

Wackerly, D., Mendenhall, W., & Scheaffer, R. L. . (2007). *Mathematical Statistics with Applications (7th ed.).* Duxbury.

Authors

Laura Jagoda, PhD
Audiological Researcher, Phonak HQ, Switzerland

Laura joined Sonova in 2020 after earning her PhD in Neuroscience, focusing on speech perception. Starting in the Sonova Consumer Hearing Business, she played a key role in integrating advanced hearing aid functionality into a consumer electronics solution. Now in the Hearing Aid Business, Laura ensures that innovative technology addresses audiological needs and brings tangible benefits to users.

Niklas Ignasiak, PhD
Team Lead R&D, Phonak HQ, Switzerland

Niklas joined Sonova in 2021, leading a team that implements new data points in the product and conducts related data analytics. He has a background in human movement science and previously taught statistics at university. His passion lies in deciphering the "signal from the noise," a pursuit that drives his current work in improving hearing technology through data-driven insights.

Ina Seel,
Senior Manager Reliability Marketing Program, Phonak HQ, Switzerland

Ina joined Phonak HQ in 2021, bringing extensive expertise as an audiologist and regional area manager. She earned her Master Hearing Aid Specialist certification in 2012. As Launch Program Manager, she was key in the global introduction of the Slim Lumity hearing device. Now, as Senior Manager of Reliability Marketing Programs, she identifies customer needs and ensures product quality and reliability to enhance user satisfaction and trust.

Franziska Schubert, PhD
Data Scientist, Phonak HQ, Switzerland

Franziska joined Sonova in 2023, bringing a robust background in computational physics and data science. After earning her Ph.D. at the Fritz Haber Institute of the Max Planck Society, she gained industry experience in developing neural networks aimed at optimizing operational efficiency. She now focuses on leveraging advanced data techniques to extract insights that enhance hearing aid product performance and user experience.

Anne Thielen, PhD
Director In Market and Data Management, Phonak HQ, Switzerland

Since 2023, Anne has held the role of Director of In-Market and Data Management at Sonova Hearing Aids Business. She earned her degree in Microsystems Engineering in 2013 from IMTEK, University of Freiburg, and MIT, USA. In 2018, she completed her Ph.D. in Applied Solid State Physics at ETH Zurich. Following this, she focused on transforming hearing instruments into body-worn IoT devices within Sonova's R&D department. Her current interests include data innovation, classifier integration, and servitization.