GREENWOOD ENGINEERING

Your way to outstanding condition surveys
in the global **road** and **railway** industry

GREENWOOD ENGINEERING

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OUR HISTORY

Greenwood Engineering was founded in Denmark in 1992 by CEO Leif Grønskov. The first project was a road profiler with 17 laser and inertial system, developed by Leif Grønskov in corporation with his late father Niels Grønskov.

Soon after, the first MiniProf system was introduced and during the years, the products have been enhanced and numerous new products have been added, including the LaserProf, the Profiler and the Traffic Speed Deflectometer.

Today, Greenwood has approximately 50 employees, thousands of users, a strong global agent network and local offices in Copenhagen, New York and Beijing.

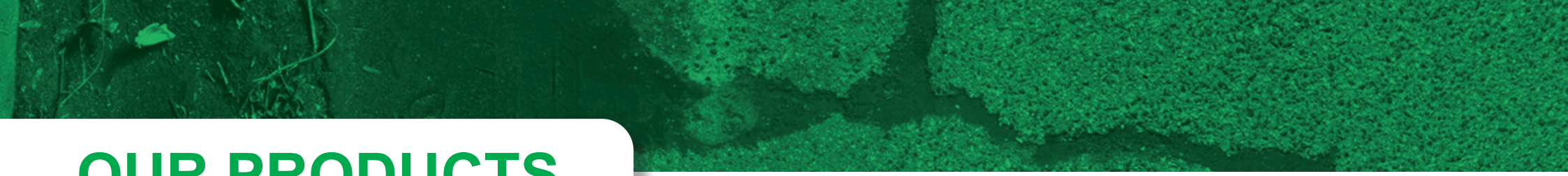
We are characterized by a dedicated and innovative company spirit, a close collaboration with our customers and a very high level of technical in-house knowledge and talent. The majority of the Greenwood employees are highly skilled engineers and technicians. Some key employees have seniority up to +25 years, some have joined us along the way and some are fresh out of university or Ph.D.

Combined, with a strong and experienced sales department and back office, Greenwood is built on solid ground and continues to offer outstanding products and new developments. **We welcome you to join the ride!**

30 years on the market, still going strong and the rest is history!

Leif Grønskov presenting one of many Greenwood products.

One of the first road profilers with 17 laser and inertial system.



OUR PRODUCTS

HIGHLY SPECIALIZED MEASURING EQUIPMENT

Greenwood Engineering develops and manufactures advanced equipment for:

- Structual and functional pavement condition measurements in the global road sector. All systems are designed to suit research level as well as routine survey operations. Design and software are made in-house allowing for customized modules to be created to assure data continuity for the road administrations.

- Full contact profile measurement system for wheels, brakes and rails in the global railway sector.

Greenwoods wide product range spreads from the small, handheld and lightweight MiniProf units for monitoring and analyzing the cross-sectional profile of train wheels, rails and brakes, to the truck size Traffic Speed Deflectometer (TSD) for both network level and project level bearing capacity measurement on roads while driving at normal traffic speed.

AT THE FOREFRONT OF TECHNOLOGY

Our products are operated with minimum disturbance to environment and traffic and with the highest user safety and comfort in focus. The solutions provide outstanding measuring results and constitute an extremely reliable foundation for making critical and economic decisions in maintenance, quality and safety departments all over the world.

Much has happened since the first projects were launched in 1992, but one thing remains unchanged: the basic premise for all marketed products is to be at the leading edge of frontier technology. Greenwood has an innovative company spirit and a close relation to our customers.

GREENWOOD PROVIDES

- ✔ Highly reliable measurement data for cost-effective maintenance planning
- ✔ State of the art products based on in-house research and development
- ✔ Excellent service and support, provided by a wide range of skilled staff (Ph.D´s, mechanical and electrical engineers, software developers, craftmen etc.)

Advanced measurement equipment for cost-effective maintenance planning

ON THE ROAD WITH TSD

TRAFFIC SPEED DEFLECTOMETER (TSD)

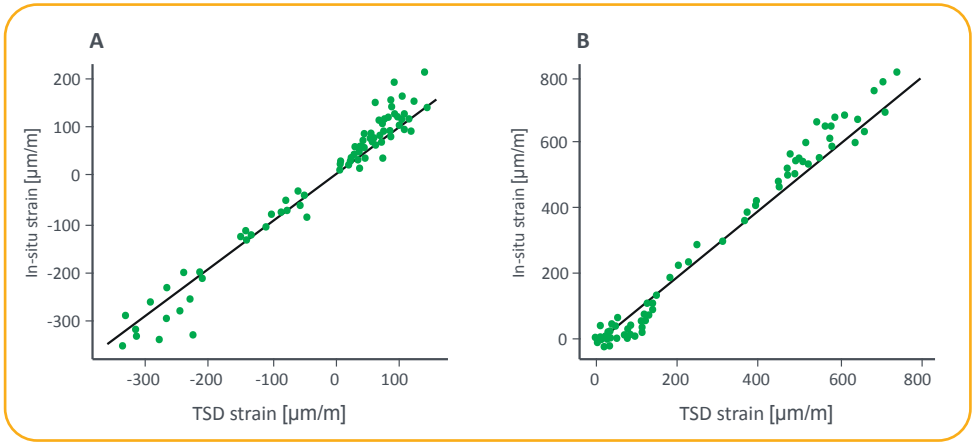
The TSD is a well proven Rolling Wheel Deflectometer measuring pavement response to an applied load. The unique TSD technology is developed by Greenwood Engineering and has initiated a shift of paradigm in global pavement engineering.

With no lane closures, the TSD provides continuous bearing capacity results at project and network level while following the flow of traffic. This makes it possible to measure hundreds of kilometers per day and makes the TSD highly cost effective.

TSD-MEASUREMENTS VALIDATED ON AN INSTRUMENTED ROAD

Results from a comprehensive set of validation measurements illustrate the ability of the Traffic Speed Deflectometer's (TSD) to accurately measure the actual pavement deflection compared to in-situ displacement transducers.
Applying a linear viscoelastic back-calculation algorithm to the TSD, measurements produces estimates of stresses and strains inside the pavement structure.

The tests reveal an excellent agreement between the surface deflection measured by the two systems, and as seen below a good agreement between the strains predicted from TSD measurements and the strains measured by in-situ transducers.



A.: In-situ peak transversal strains plotted versus TSD peak transversal strains.

B.: In-situ peak vertical base course strains plotted versus TSD peak vertical base course strains.

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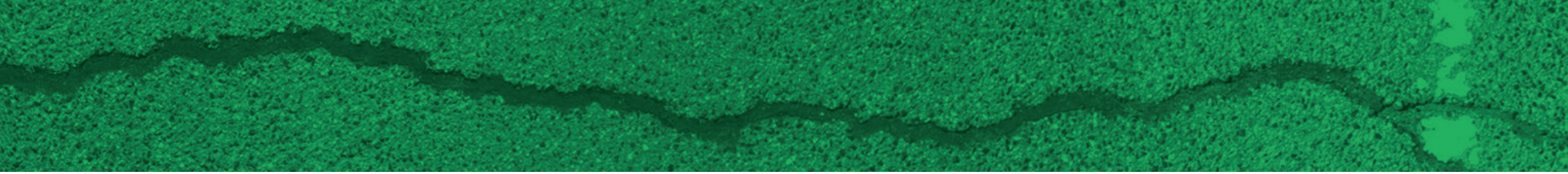


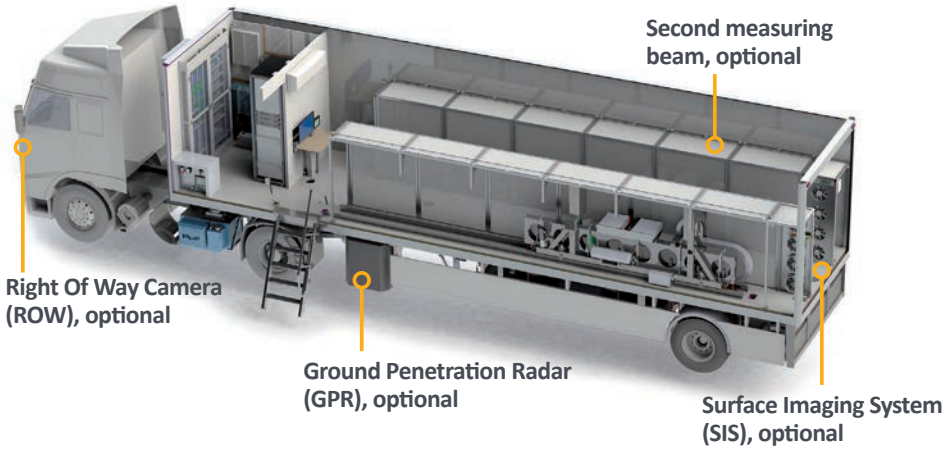
CUSTOMIZED PRODUCTS

Our products are based on more than 25 years of development and user experience from customers in more than 50 countries.

Greenwood products are well-proven technology combined with a flexibility to suit local requirements and customers specifications. For the TSD, this may include optional equipment as Ground Penetrating Radar (GPR), Surface Imaging System (SIS), Right Of Way Camera (ROW) etc. for collection of a full set of syncronized road data in one drive.

More than 20 TSD delivered in Europe, Australia, USA, Africa and China incl.:

- Doppler laser system for continously deflection measurements in the longitudinal centreline between the rear twin wheels
- Special designed trailer and wheel hubs for measuring behind as well as in front of the rear load axle
- Servo system and inertial units continuously monitor and control the position of the Doppler sensors



TSD DELIVERS BACK-CALCULATED STRAINS WITH 1 M RESOLUTION

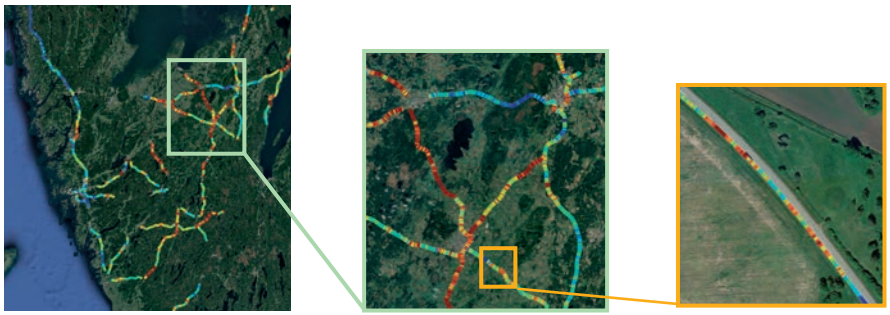
Based on the measured layer thicknesses and pavement response data, the pavement strains and the elastic moduli of each layer can be found using Greenwood's own viscoelastic back-calculation algorithm.

Having access to detailed back-calculated results at the network level makes it possible to make reliable life-time analyses for the entire road network and to identify appropriate preventative measures in every instance.

When 'the full picture' is known for every part of the road network, it is possible to plan pavement maintenance without any unknowns and to use maintenance funds in a truly smart way.

Back-calculated fatigue strain

Fatigue strain with 1 meter intervals. Bearing capacity and the pavement layer thicknesses were measured in one go.



1 km. resolution | 100 m. resolution | 1 m. resolution

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EVERY CRACK COUNTS

DISCOVER AND MONITOR CRACKS FROM THE EARLY STAGE TO REPAIR

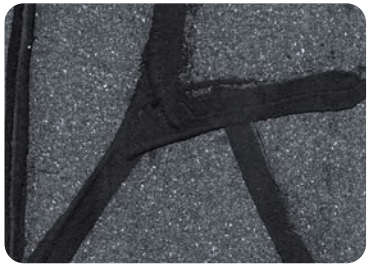
- Alligator cracking
- Longitudinal and transversal cracking
- Not visible bottom-up cracking
- Concrete slap cracking

Using the high resolution Surface Imaging System (pixel resolution of only 1 mm) and the high frequency Doppler laser system (sampling rate 250 kHz) allows road authorities to locate even very small cracks. This enables planning of early and correct repairs, and reduces the total minimum cost.

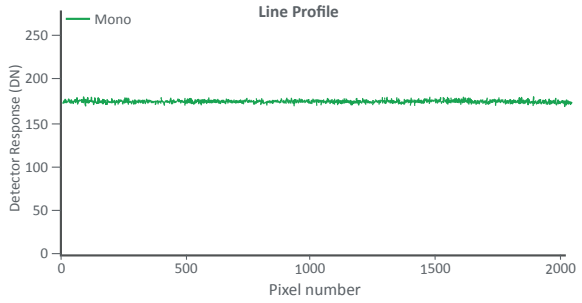
SURFACE IMAGING SYSTEM (SIS) – HIGH-RESOLUTION SURFACE IMAGES FOR CRACK DETECTION ANALYSIS

- High-resolution pavement imaging system based on linescan camera technology.
- SIS records the road pavement as one continuous uninterrupted image that can be exported in image blocks with a user selected length.
- High-power efficient LED based light system.

SIS can be configured for user needs with up to 4.5 m measuring width and pixel resolutions down to 1 mm. Images are tagged with travelled distance from a DMI and GPS coordinates if available on the vehicle for precise co-location with data from other measurement systems.

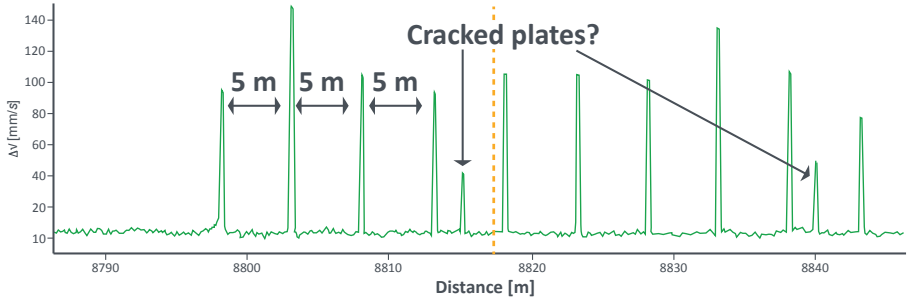


Camera line profile after factory calibration of the LED based light system.



TSD MEASUREMENTS ON CONCRETE PAVEMENT

- Locates varying load transfere between concrete slaps
- Finds cracks on slaps
- Works on open concrete and concrete under asphalt



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Optimum airport maintenance by continuous bearing capacity measurements with the Traffic Speed Deflectometer

MOTIVATION FOR RUNWAY MEASUREMENTS

- **Avoid unforeseen close down due to**
  - Longitudinal unevenness
  - Rutting
  - Fatigue cracker
  - Potholes

WHY MEASURE AIRFIELDS WITH A TSD?

- **Speed**
  - Higher productivity
  - Can measure during normal operation
- **High spatial resolution**
  - Continuous measurements
  - Highly repeatable
  - Measures on asphalt and on concrete
  - Find small weak areas
  - Full overview of bearing capacity
- **Measures response to moving load**
  - Realistic effect of inertia
  - Realistic effect of viscoelasticity

LASERPROF AND PROFILER

LASERPROF

The LaserProf is a compact and portable profiler for reading texture (MPD) and/ or roughness (IRI), and can be mounted on a standard tow hitch. It can have one or two laser sensors, reading in the wheel paths, and is designed to be a tool for the pavement supervision engineer making quality control.

The LaserProf has been implemented in the LaserProf BikeLaneTrailer for measuring bikecycle lanes. GPS and Right-of-Way camera (ROW) can be added to the LaserProf.

PROFILER

The Profiler provides both transverse and longitudinal profiles, and allows them to be combined in one 3D profile. It optimizes management of pavement maintenance. Greenwood Profiler uses high precision sensors and digital data acquisition for highest possible result quality and can be operated as a standalone system or as part of a multifunction vehicle.

It is configurable to meet many different requirements and can be synchronized with GPS and other measurement systems like Surface Imaging System (SIS) and Right-of-Way Imaging.

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ON THE TRACK WITH MINIPROF

MUCH MORE THAN A MEASUREMENT

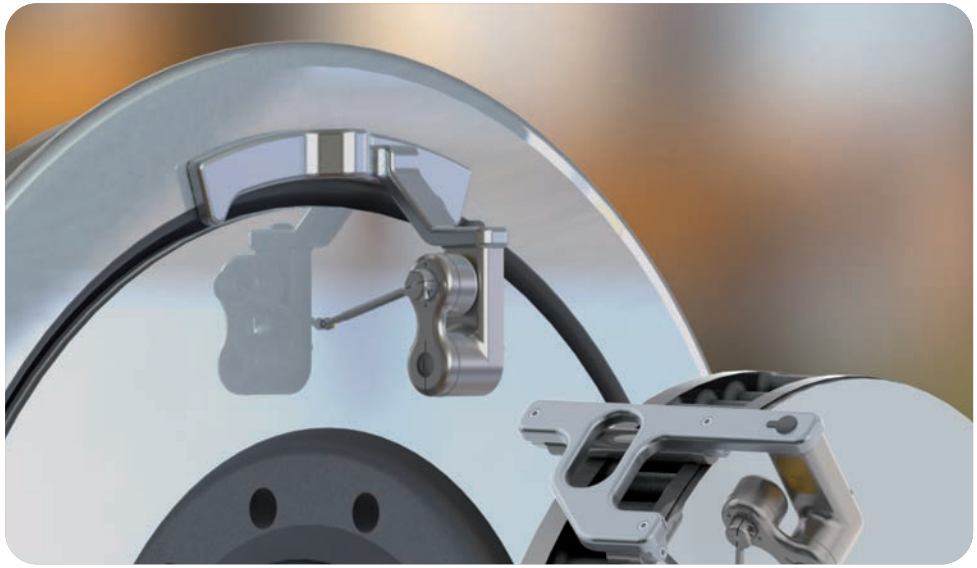
The MiniProf systems are used by thousands of customers in the global railway industry for high-precision cross-sectional profile measurements. Made from ultra-strong titanium and based on the full contact measuring principle, they are fast, stable and easy to use and provides the absolute best accuracy available on the world market.

Combined with the strong Envision software which contains numerous calculations and alignments, it enables the user to monitor and analyze the wear and to make critical decisions within railway maintenance, quality and safety all over the world.

MINIPROF RAIL

The MiniProf BT Rail system is magnetically attached to the top of the railhead. The rail profile, track gauge, super elevation and grade is measured simultaneous in one single measurement in less than 5 seconds. The vertical, horizontal and angled wear displays instantly in real time view and residuals and areas can be visualized and calculated automatically.

GPS locations can be logged for easy identification of special points of interest along the railroad track.



MINIPROF WHEEL

A MiniProf BT Wheel is magnetically attached to the backside of the wheel and measures the wheel profile in less than 5 seconds and a complete railroad car in less than five minutes. It can be used on most types of wheels from trams to locomotives and measures the profile and the wheel diameter in one single measurement depending on configuration.

Wear parameters such as Sd, Sh and qR values are displayed instantly and residuals and areas can be visualized and calculated automatically.

MINIPROF BRAKE

MiniProf BT Brake can be delivered for wheel or axle mounted brakes. It is magnetically attached to the wheel or axle and the brake profile is measured in less than 5 seconds. It provides instant calculations of the brake hollowing and brake thickness.

The MiniProf Envision software can visualize and calculate residuals and areas automatically. Measurements can be compared in multiple ways and easily exported to various formats.

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THE WORLD OF GREENWOOD

Greenwood Engineering is a Danish company with a large international profile. With products distributed and used successfully all over the world by thousands of users, a vast agent network.

We have local offices in Copenhagen, New York and Beijing.

Greenwood Engineering are proud to be a strong and contributing factor to the global optimization of road and railway conditions.

CONTACT US FOR MORE INFORMATION

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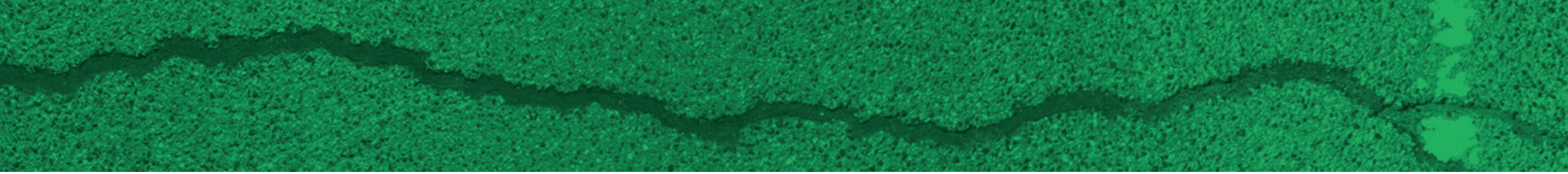

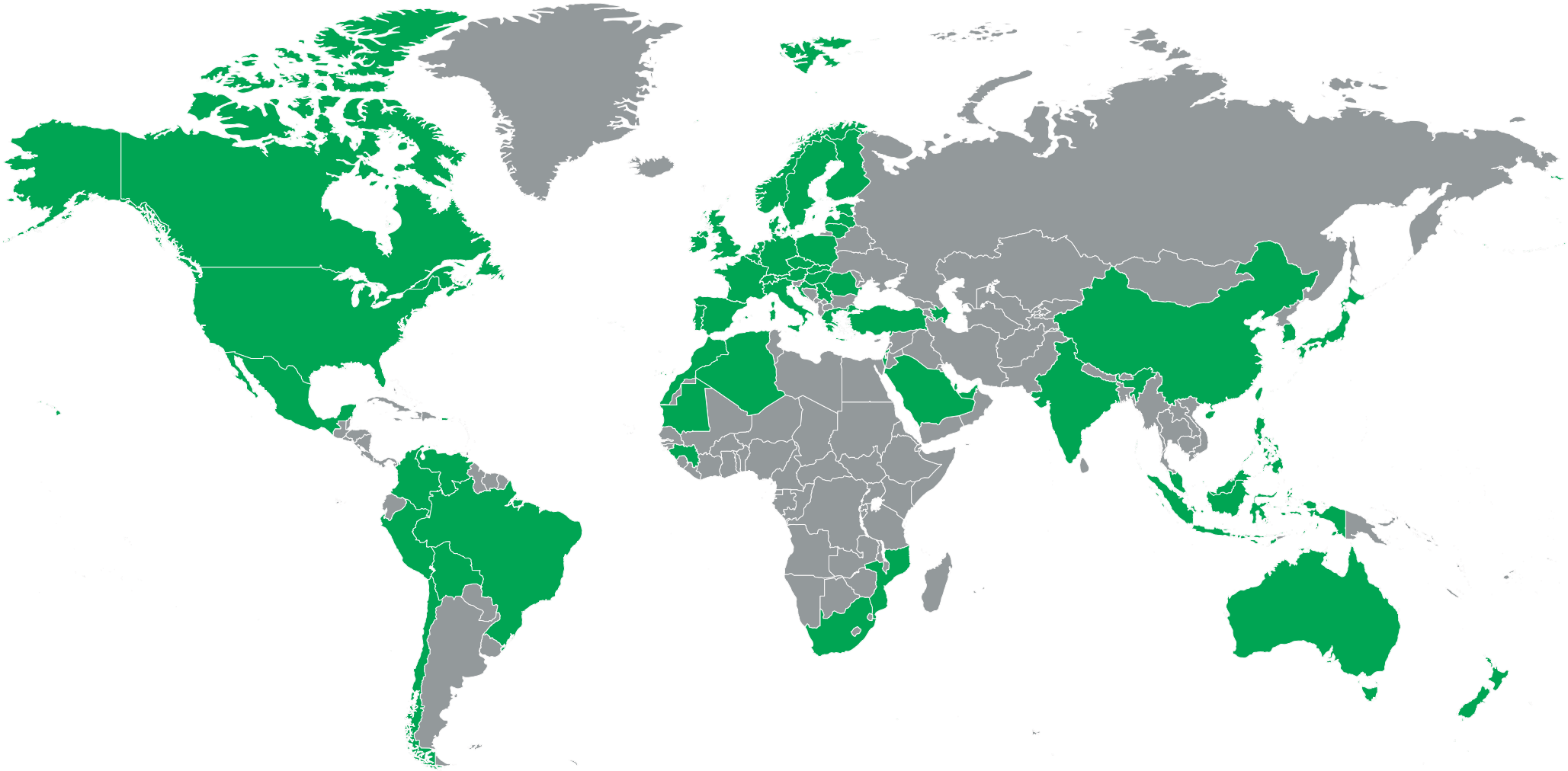

OUR CUSTOMERS AROUND THE WORLD

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