



2020 Products & Services Guide

AERIAL PHENOTYPING FOR RESEARCH & BREEDING

“SlantRange has proven to be a best-in-class aerial phenotyping solution and trusted development and integration partner through multiple seasons as we scale up our program.

As a result, Syngenta is expanding its use of the SlantRange platform across multiple business units and application areas. Their focus on agriculture and long-term vision for technology in 21st century agriculture makes them a great asset in Syngenta’s quest to innovate sustainable agriculture solutions.”

Dr. Adrian Lund
Principal Research Scientist



THE DATA ANALYTICS PLATFORM FOR RESEARCH & BREEDING



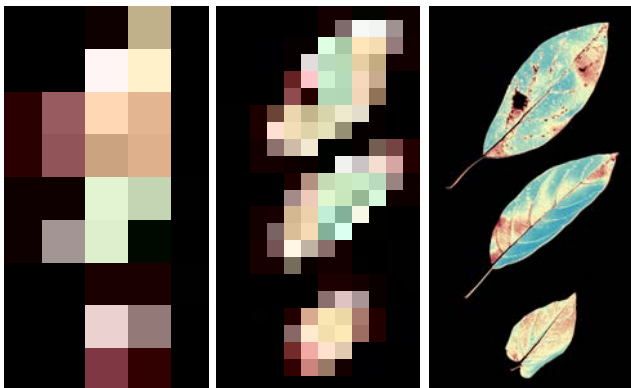
The Power of Low Altitude Measurement

MORE ACCURATE, COMPREHENSIVE DATA TO DRIVE RESEARCH & BREEDING

Low altitude remote sensing can deliver the plant development data that enables more efficient, predictable, and sustainable food supplies.

Researchers and breeders, long constrained by the difficulty in obtaining accurate and objective measurements of their trial programs, now have an automated tool to capture that valuable data.

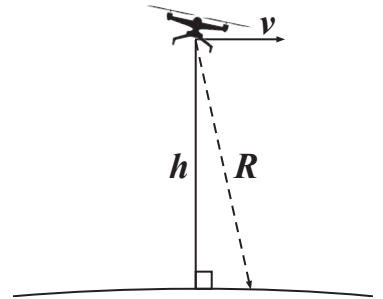
Aerial measurements have been attempted for decades but with limited success. Newer, low-altitude systems however (those operating at or below about 100 m altitude) have advantages that are driving through past limitations. These systems can surpass the “Johnson Criteria” at very low cost, an important remote sensing concept that describes how new classes of information can be derived from imagery when the resolution becomes substantially better than the object being measured (in this case individual leaf features) - information that cannot be obtained at lower resolution.



The high resolution of low altitude remote sensing enables new plant development information

How does low altitude measurement deliver value?

- Low altitude, robotic systems can exceed the Johnson Criteria at low cost whereas higher flying satellites and manned aircraft cannot. This enables plant signatures to be isolated from the signatures of background soils, shadows, weeds, or other field residue to eliminate errors and improve sensitivity.
- Individual plants can be isolated and classified into different species groups.
- Phenotypical measures of plant development such as size, shape, morphological structure, and biomass become possible.



Simply collecting high resolution images isn't enough however. Extracting this new information requires technical methods designed specifically for the task.

This guide introduces SlantRange's remote sensing and analytics tools designed for phenotyping agricultural trials. The data supplied by these systems is enabling breeders and researchers to more accurately determine how traits and treatments will perform under real-world conditions - and that will drive improved farm productivity and visibility into yield.



Spectral measurements

"Spectral" imaging is gaining popularity in agriculture to assess plant health conditions. But the technique is complex and can lead to inaccurate results if misapplied.

A plant's interaction with sunlight reveals information about its chemical and physical composition, information that can be correlated with its genetic traits and other treatments to characterize performance under a given set of conditions and to predict potential future performance.

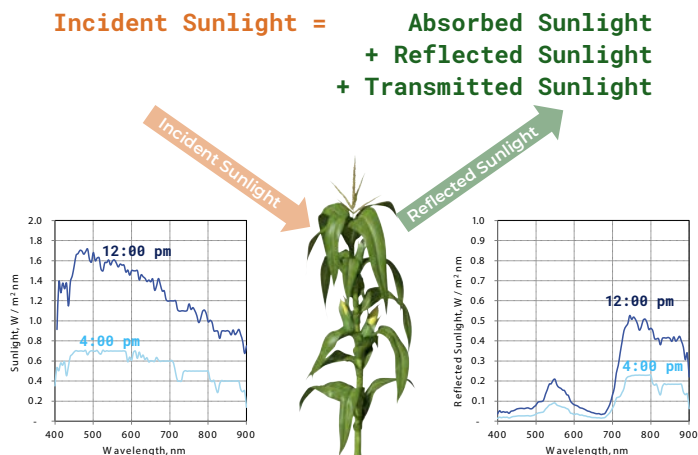
to determine what was absorbed by the plant. Accuracy requires spectral measurements both before and after the light interacts with the plant. Otherwise, even minor changes in sunlight conditions will impart errors in the measurement.

To solve this, SlantRange introduced new technology to simultaneously measure incident and reflected sunlight from plant canopies so that accurate plant health can be measured in real-world conditions.

SlantRange has patented this method.

Spatial measurements

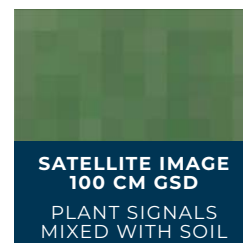
Low altitude systems offer a second major advantage. They enable individual plants and leaves to be isolated for analysis of their spectral signature as well as their size and shape as shown in the example below.



The spectral signature of incident sunlight must be known to accurately determine plant condition

Spectral imaging measures this plant/sunlight interaction for markers of plant pigments, moisture content, or cellular structure indicative of health condition.

To do this accurately, the spectrum of light reflected from the plant is subtracted from the incident light spectrum



SlantRange has introduced new analytical methods that make use of plant morphology to more accurately, and more comprehensively describe plant development throughout the growing season.

SlantRange has patented some of these methods.

The following pages introduce these SlantRange sensing and analytics technologies in greater detail.

Integrated Measurement Systems

THE STARTING POINT FOR ACCURATE DATA & MEANINGFUL ANALYTICS

The SlantRange / DJI Aerial Phenotyping System

Aircraft	DJI Matrice 200 V2
Sensor	SlantRange 4P+ w/ Precision Navigation Module
Spectral Channels	6
Spectral Range	410 - 950 nm
Band Positions¹	470, 520, 620, 670, 720, 850 nm
GSD @ 100 m AGL	2.2 cm
Detector Type	Si CMOS
Shutter Type	Global
Onboard Navigation	RTK GNSS/IMU with EKF
In-Flight Data	Setup, Status, Coverage
Onboard Storage	64 GB (2 hours)
Image Format	GeoTIFF
Max Flight Time	24 minutes
Aircraft Size	34.9 x 34.6 x 14.9"
Aircraft Weight	Approx. 5 kg

¹Band positions are selectable at time or order.
Some conditions apply, please call for details.

Patented technology for accurate spectral measurements

SlantRange introduced its first spectral sensing systems for agriculture in 2014 and continues to innovate new improvements for accuracy and efficiency.



SlantRange's initial prototype incorporated the industry's first on-board sunlight calibration capability for spectral accuracy. In 2019, SlantRange integrated RTK GPS and a laser altimeter to deliver greater accuracy of plant morphological measurements.

With over 2x higher spatial resolution than its nearest competitor, SlantRange sensors, unlike alternatives, were designed specifically for aerial phenotyping.

US Patent 9,470,579
US Patent 9,791,316
Australia Patent 2015315327
Canada Patent 2,960,375
Canada Patent 3,046,667

A robust, industrial measurement system, built for enterprise agriculture

In 2018, SlantRange announced a robust and tightly integrated new platform for agricultural data collection in partnership with DJI, the world's leading commercial/industrial drone supplier.

The SlantRange 4P Series sensor system brings all new levels of workflow efficiency and in-flight data accessibility to DJI's Matrice 200 Series aircraft. This integrated system delivers SlantRange's trusted spectral sensing capabilities and ultra-high accuracy RTK-based positioning on a robust flight platform - a reliable tool for day-to-day enterprise operations.



Analytics & Data Products

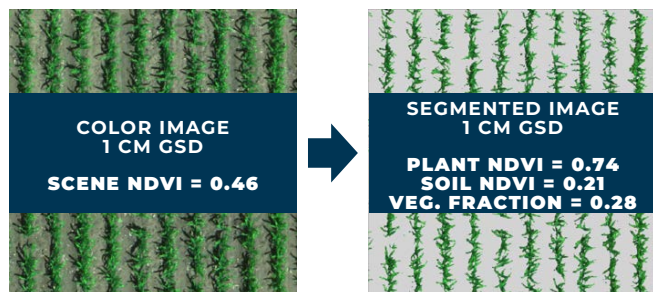
MORE ACCURATE ANALYSIS, MORE RELEVANT DATA

SlantRange's patented analytical methods are delivering improved analytical accuracy and processing efficiency.

Plant Segmentation

SlantRange employs intelligent computer vision techniques to segment features in imagery - so analysis will be focused on the crop population and not the surrounding soils, weeds, or residue.

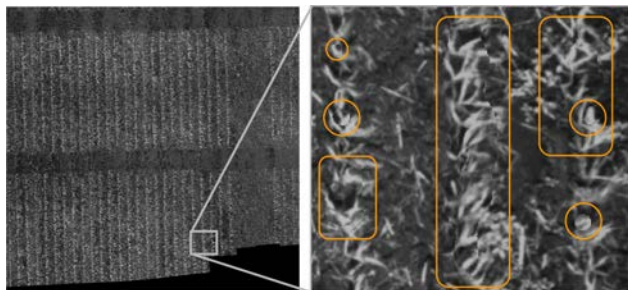
US Patent 10,318,810



Direct Geopositioning

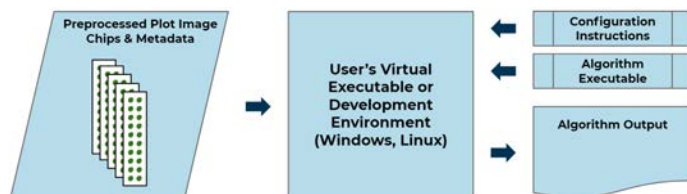
Traditional image stitching is computationally intensive. It also introduces artifacts (example below) that corrupt rigorous analyses of image content. SlantRange employs a new method that eliminates the stitching process to deliver more accurate results and a greater diversity of data products with up to 10x lower computational costs.

US Patent 10,217,188



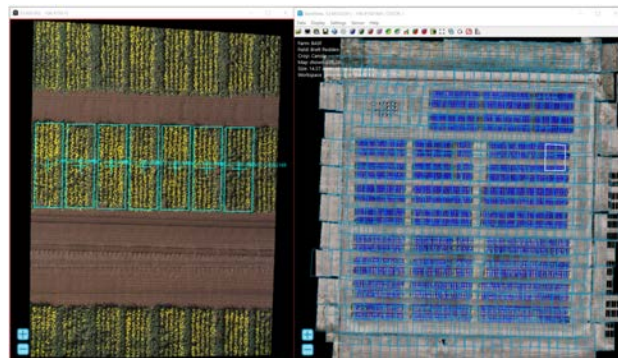
User-Defined Algorithms

Do you already have processing algorithms you'd like to use? Or are you looking to develop your own? SlantRange enables user-defined algorithms to be inserted into the processing workflow. All of the image calibration, preprocessing, and georeferencing are handled by the SlantRange platform and spectrally-separated image chips are delivered to your own virtual "black box" development workspace to run your own image analysis.



Quality Control

Multiple automated (and manual if desired) checks of data validity are included in SlantRange's workflow, beginning at the point of data collection and ending with the delivered data products.



SlantRange includes multiple stages of data validity checks for quality assurance (in-field tool shown)



SlantRange's Data Products

New for 2020, SlantRange's aerial phenotyping is available for both multispectral and RGB sensor options. Data product availability is subject to crop type and maturity, and collection parameters as described below.

If there's a desired trait or crop application that is not listed, contact us for developmental options. SlantRange has delivered data on over 100 crops and is continually developing solutions upon client request.

DATA PRODUCT	CORN	SOYBEAN	WHEAT	COTTON	CANOLA	SORGHUM	CUCURBIT
Plant Population (Density, Count) ¹	●			●		●	
Plant Size ¹	●			●		●	
Emergence Fraction	●	●	●	●	●	●	●
Vegetation Fraction	○	○	○	○	○	○	○
Chlorophyll Index	●	●	●	●	●	●	●
Yield Potential	●	●	●	●	●	●	●
Vegetation Stress	●	●	●	●	●	●	●
Maturity Date ²	○	○	○	○	○	○	○
Flowering					●		
Plant Height	○	○	○	○	○	○	○
Weed Population (Density, Count)	●	●	●	●	●	●	●
Spectral Indices (e.g. NDVI)	●	●	●	●	●	●	●
Greenness Index	○	○	○	○	○	○	○
Absolute Reflectance	●	●	●	●	●	●	●
Plot Images	○	○	○	○	○	○	○
RGB (Color) Orthomosaics	○	○	○	○	○	○	○
Plant Lodging (Developmental)	●	●	●		●	●	
Spike Density (Developmental)			●				

● Products available only with sunlight-calibrated, narrowband multispectral sensors.

○ Products available with RGB or narrowband multispectral sensors.

¹ Available within a maturity window shortly after emergence.

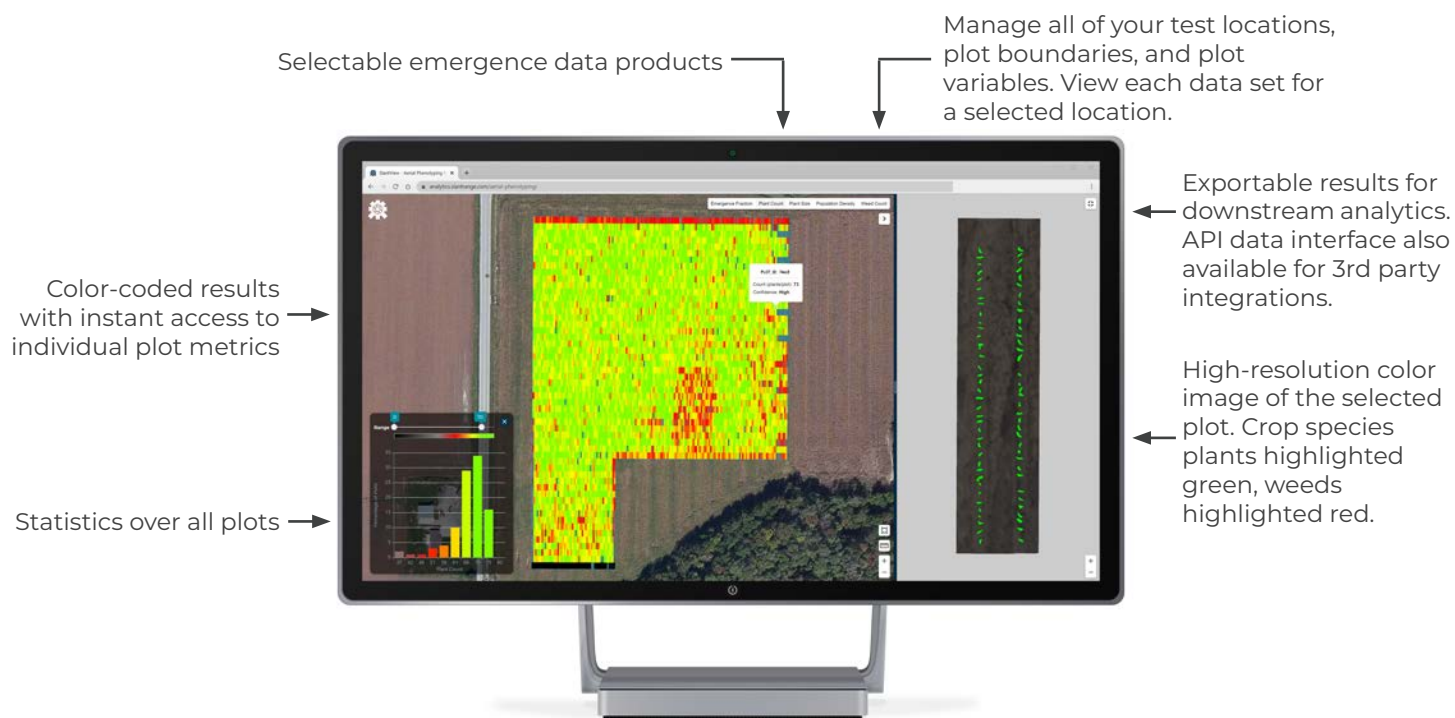
² Definition varies by crop type.

³ Not all data products are available for all sensor types (e.g. RGB, multispectral).

SlantView - AP

THE FIRST PLATFORM FOR AERIAL PHENOTYPING

Easy-to-understand results across all of your trials, from emergence...



An End-to-End Data Platform

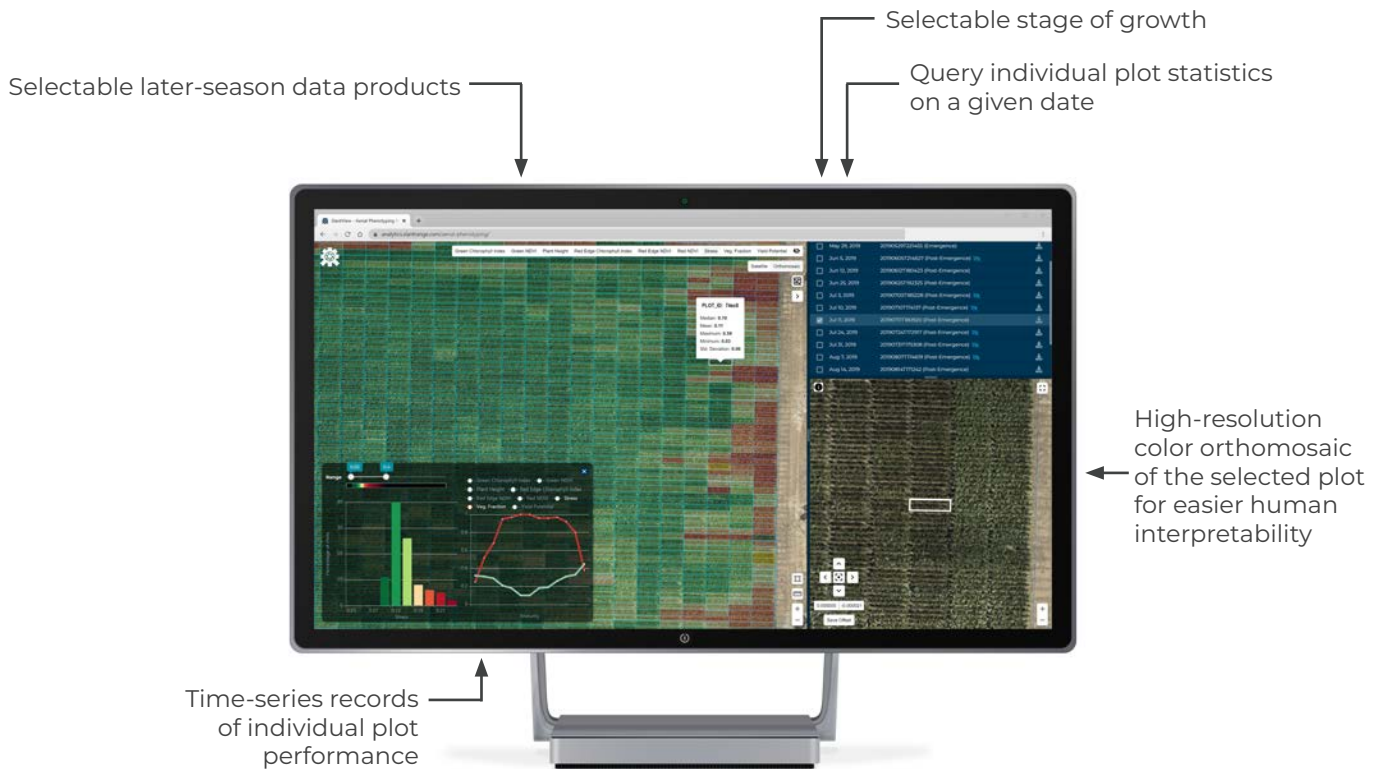
SlantView - AP is the first platform designed for aerial phenotyping on an enterprise scale, from aggregating and managing data collections across multiple locations to analysis to data visualization and reporting.

Trial Configuration

Import or define the geographic and descriptive attributes of your trials to be managed and analyzed together with your aerial data.



...through full-season maturity



Management, Analysis, Visualization

Ensure the timing and quality of your measurements throughout the season with online data status, analysis, and visualization capabilities.

Data Interfaces

Transfer data into 3rd party or proprietary platforms for further analysis with easy exports and APIs.

Tiered Solutions to Meet Your Program Needs



Basic

Self-Managed RGB Analytics

1. Prepare your own plot definitions
2. Collect your own data
3. Upload to SlantView Cloud
4. Adjust and verify plot alignment
5. View/export plot trait statistics



SlantView - AP Cloud
Optimized Uploader
Plot-Level Exports
RGB Analytics
Multispectral Analytics
Time Histories
Advanced Analytics
Custom Algorithms
Plot Pattern Generation
API Access
In-Field Quality Check
Priority Support

Enterprise

Full Service Aerial Phenotyping

1. Plan your program with SlantRange
2. SlantRange prepares plot definitions
3. Manage your own data collections or have collection service provided
4. View/export plot trait statistics



Scalability for All Organization Sizes



SlantRange's aerial phenotyping platform is designed to scale from the needs of a small Contract Research Organization (CRO) to a global agri-business enterprises.

Analytics Engine Hosting Options

The SlantView - AP analytics engine can be hosted on our servers or deployed within your IT infrastructure for tighter integration with the other components of your business.

External APIs

APIs are available to exchange data with other platforms:

- Trial management software
- Planter or harvester data
- External databases

Algorithm Support

The SlantView - AP analytics engine includes the full suite of validated SlantRange algorithms but can also host 3rd party algorithms for supported sensors.

Custom Analytics

SlantRange commonly develops new algorithms to support the unique needs of its clients. Contact us if you have a new data requirement.

Drone Program Management

SlantRange's ecosystem partners offer integrated fleet management and scheduling for enterprise drone programs, including:

- Asset management
- User management, roles, and permissions
- Scheduling
- Regulatory compliance
- Customized procedures and checklists

Data Privacy & Security

The entire SlantRange Aerial Phenotyping workflow is executed with a commitment to maintain the security and privacy of your data. Data transfers and hosting include 128-bit encryption and firewalls protect your sensitive information. User roles and permissions can be implemented if desired.

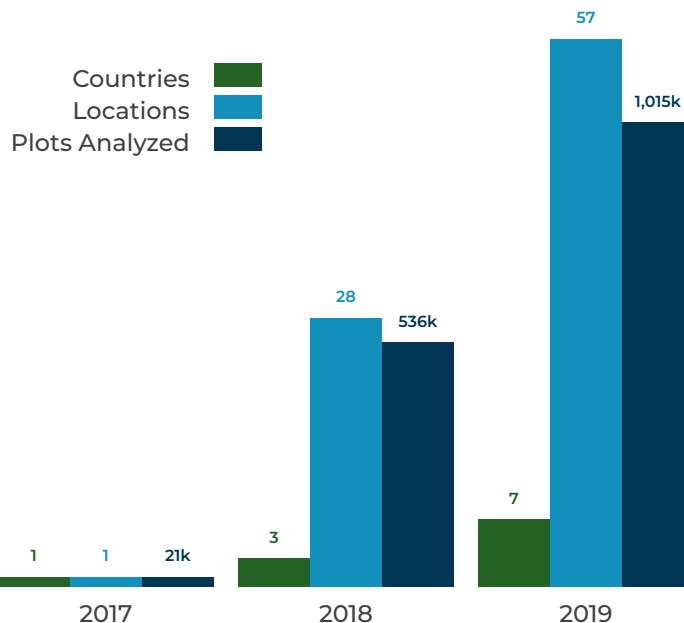
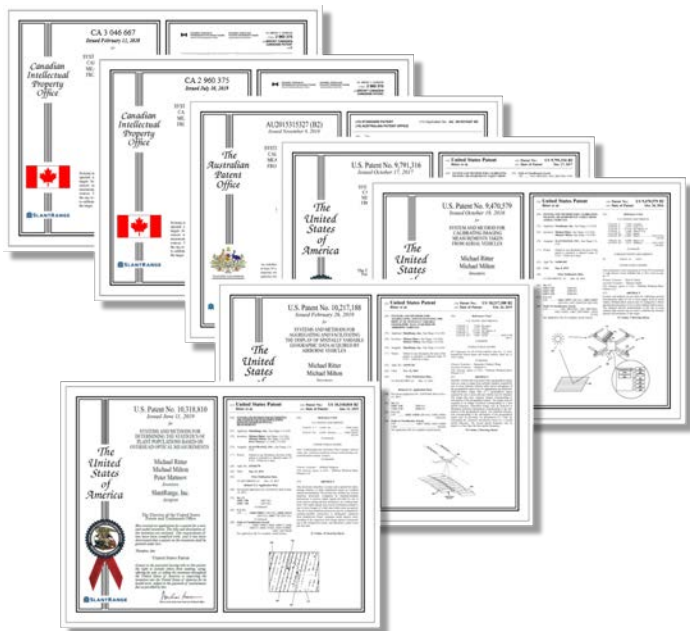
Intellectual Property to Build Upon

Leading agricultural organizations need to ensure a secure intellectual property foundation upon which to grow their digital platforms.

Validated Technology & Service

SlantRange delivers aerial phenotyping technology and services to the most advanced agricultural research & breeding organizations in the world.

Intensive ground validation studies have led to rapid adoption of SlantRange's more accurate and comprehensive methods.



Secured Intellectual Property

SlantRange has developed and captured intellectual property underlying foundational technologies for aerial crop measurement, including 7 multinational patents spanning:

- On-board calibration of spectral imaging systems to correct for variable lighting conditions
- Plant segmentation analytics enabling population counts, plant size distributions, and weed detection
- Processing methodology that reduces data collection and processing costs by >4x while improving accuracy

“SlantRange’s broad suite of validated analytics coupled with their robust intellectual property portfolio for aerial measurement technologies made them an ideal partner as we continue to expand our research and development platform.”

Dr. Peter Lynch
VP of Research





THE DATA ANALYTICS PLATFORM FOR RESEARCH & BREEDING

4901 Morena Blvd. Suite 701, San Diego, CA 92117 • sales@slanrange.com • +1 858 434 1037 • www.slanrange.com