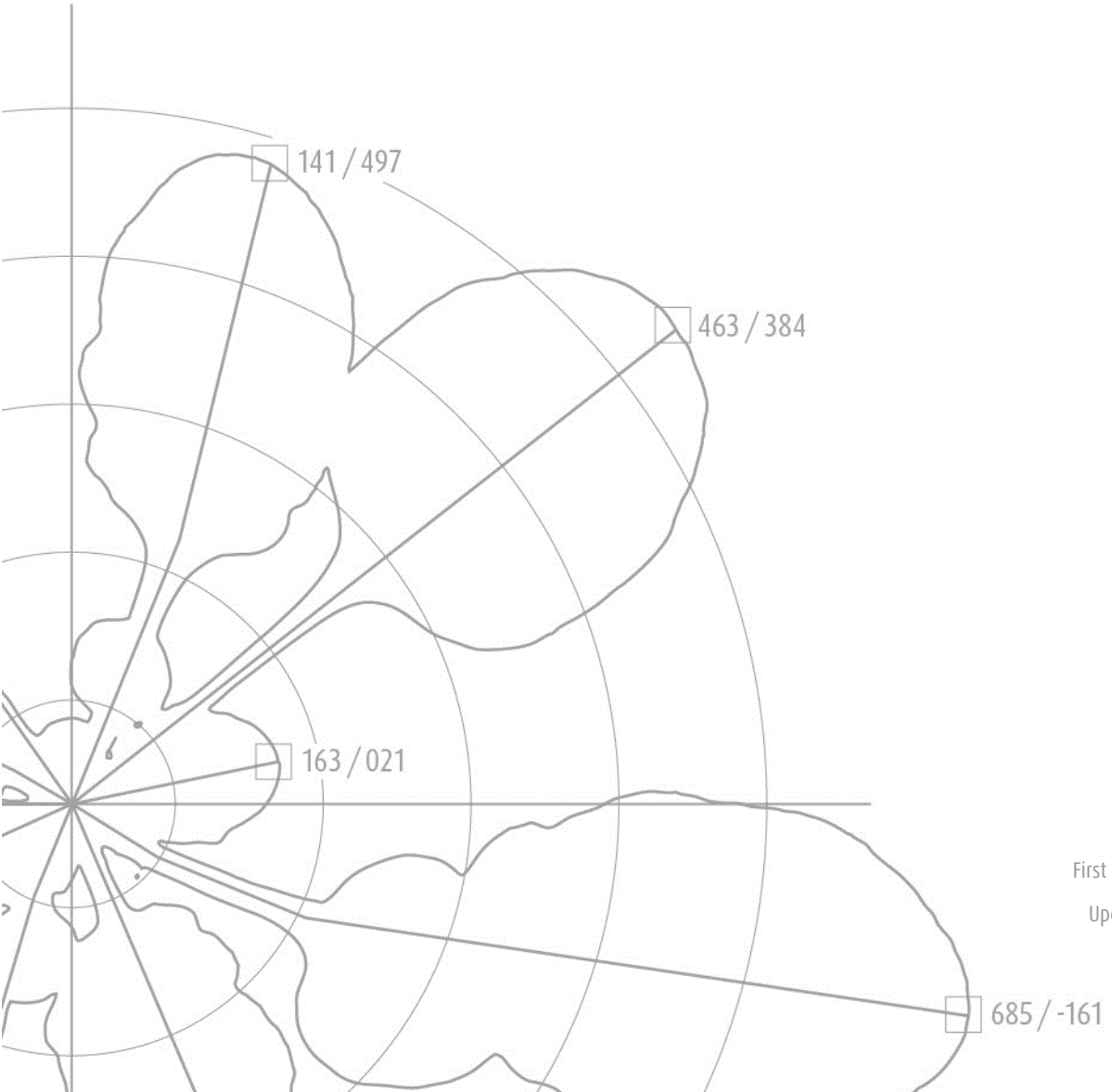
LemnaTec

ScanalyzerField

System Specification

7100019 USA Field

General Version



First issued 20. Januar 2015

Updated 29 October 2015

Localization

Delivery Address:
University of Arizona
37647 W Smith Enke Rd
Maricopa, AZ 85138, USA

The System's position is marked roughly in Figure 1 as red rectangle. Exact position has to be submitted by the customer with reference to a point of origin. The guide rails will be oriented in North-South axis, in parallel to "Cardon Ln".

Opposite the road is a marked area (Figure 1), which may be used as storage for containers or crane parts during installation.

There is an irrigation ditch between road and field. The normal field entrance is located on the field's west side. It will be checked if a concrete bridge can be installed temporarily for installation equipment.

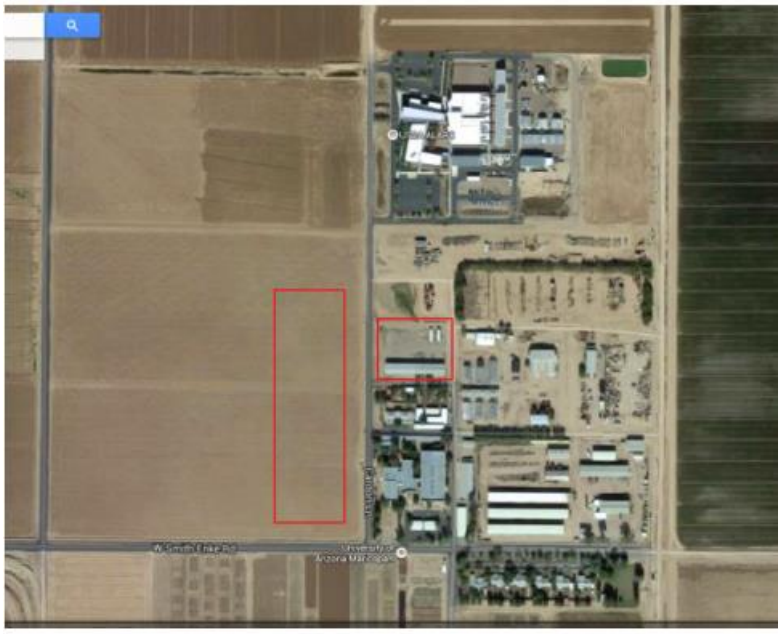


Figure 1: System location marked on satellite picture

Climate Data

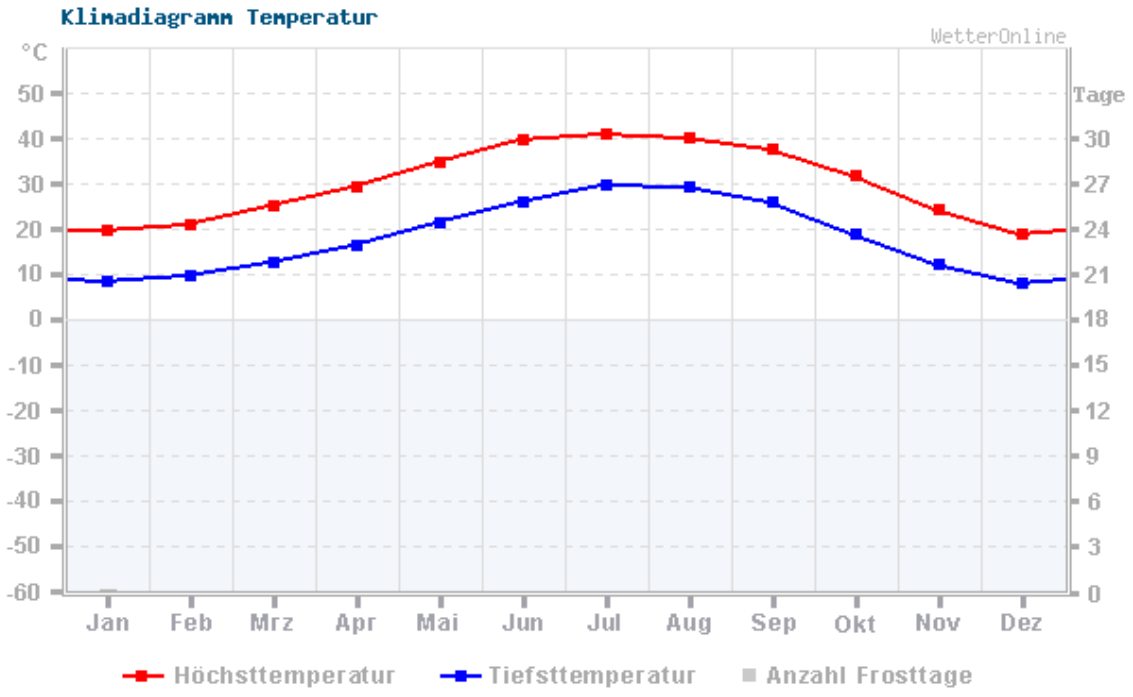


Figure 2: Temperature

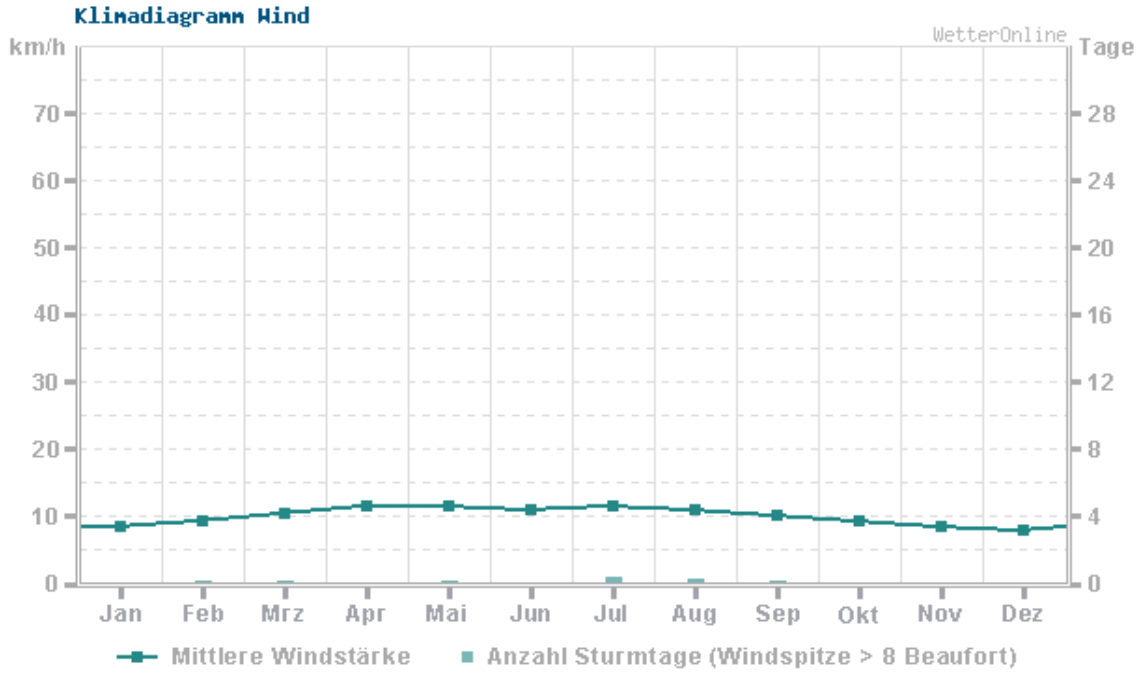


Abbildung 3: Wind

Variable	N	Mean	Std Dev	Minimum	Maximum
Year	249937	1134.48	953.3993528	87.0000000	2015.00
Air_Temp	249223	20.9536006	10.4967096	-8.7000000	47.2000000
RH	249223	41.4935483	24.9095727	-1.1000000	100.0000000
VPD	249223	1.9871995	1.7251119	0	10.3000000
Solar_Rad	249223	0.8654216	1.1683120	0	100.0000000
Precip	249223	0.0188231	0.3248076	0	45.0000000
Soil_Temp_A	249095	21.6713716	8.9727958	-2.0000000	63.8000000
Soil_Temp_B	249166	21.5832513	7.4947654	0.5000000	41.7000000
Wind_Speed_Avg	249223	2.0263491	1.3451930	0.1000000	13.9000000
Wind_Vector_Mag	249220	1.7863269	1.3660262	0	13.8000000
Wind_Vector_Dir	249220	192.9153840	90.8997053	0	360.0000000
Wind_Dir_SD	249220	28.3546946	16.7166901	0	81.0000000
Max_Wind_Speed	249062	3.6882180	2.0857187	0.0600000	29.8000000
ETo	249223	0.2318702	0.2865557	-0.0400000	12.5000000
TT_30_12_8C	139871	0.3415345	0.2896519	0	10.0000000
I	249937	15.4375823	0.4960897	15.0000000	16.0000000
Vapor_press	109352	0.9371032	0.5545016	0.0700000	3.1200000
Dewpoint	109352	4.0519789	7.9308409	-26.1000000	24.7000000

Figure 4: Weather history 1987-2015, extract

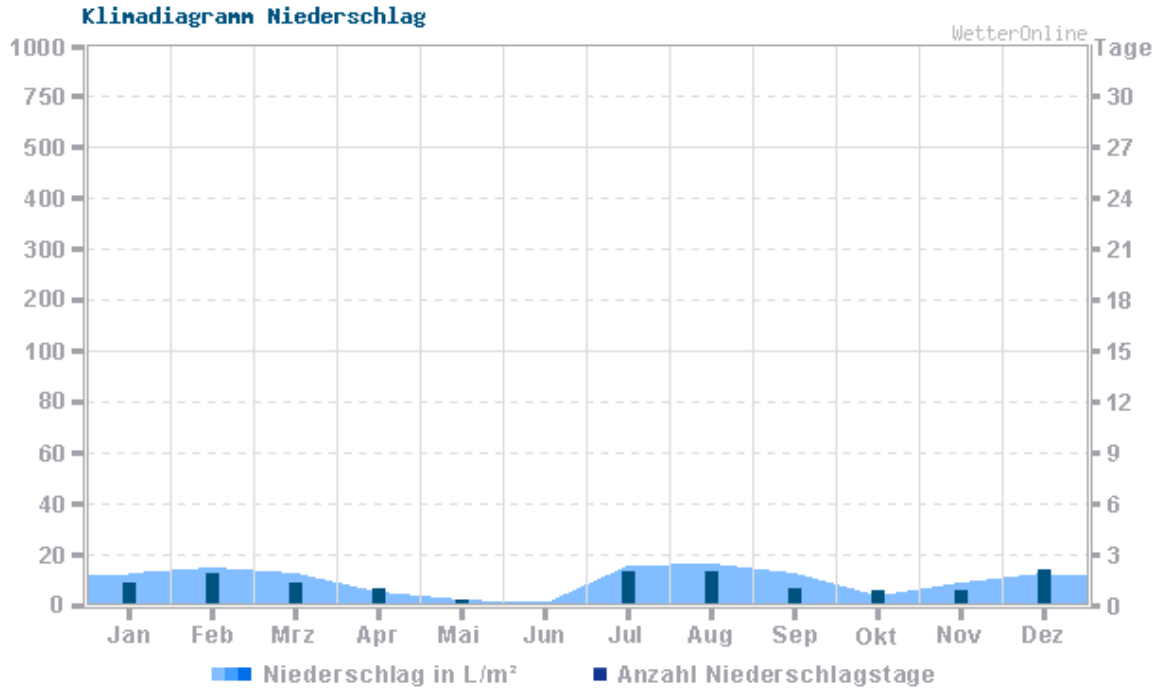


Figure 5: Precipitation

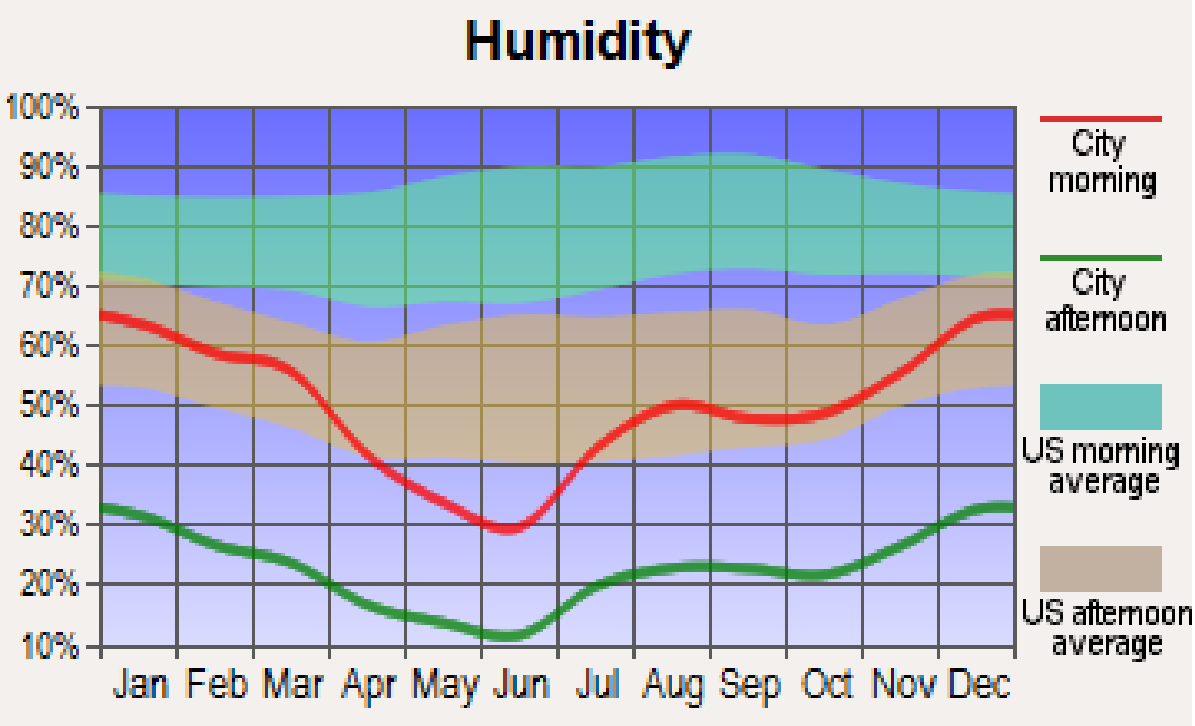


Figure 6: Humidity (http://www.city-data.com/city/Maricopa-Arizona.html)

Technical Specification

Dimensions:

System dimensions are designed for an imaging field size of at least 20m x 200m.

Width:	20m imaging area, overall width gantry crane approx. 29m, rail distance 28m.
Length:	200m imaging area, overall length gantry crane rails approx. 218,5m. The safe position with fastenings against unwanted crane movements on North or South end to be defined.
Height:	Approx. 22m with camerabox in maximum position. Bottom side of the camerabox can be lifted between 0m - 8m above rail level. The field below operational area will be levelled with tolerance of approx. 0,25m

Accuracy:

All accuracies are related to corresponding axes and are positioning accuracy. The accuracies are specified to the axes and NOT to external reference points on the ground. The measured accuracy will be better.

x-axis (North-South):	+-5cm (In Reference to the Rails)
y-Axis (East-West):	+-1cm (In Reference to the y Axis)
z-Axis (height):	+-5mm (In Reference to the z Axis)
Speed x:	60m/min (max Speed)
Speed y:	20m/min (max Speed)
Speed z:	5m/min (max Speed)

Foundation settlement

The foundation blocks will be made of concrete following detailed plans provided by LemnaTec. In general there is a time of 3 week after pouring the concrete until full loading capacity.

The foundation design assumes worst soil conditions made for minimized ground pressures. For a final statement a ground condition survey is required.

As soon as the static calculation is done, main figures can be provided to the concrete builder. Considering the agricultural influence of larger foundation blocks, the ground pressure could be reduced by increasing the foundation block size.

Basically there are three kinds of foundation settling expected:

- General settlement of all foundation blocks uniformly: This is not an issue from a technical point of view. Any height deviations can be compensated by software settings for the Z-Axis.
- Foundation settling between neighboring foundations: More than 1,5cm height difference can be critical
- Foundation settling between adjacent foundations on both rails: More than 4cm height difference can be critical

The positions and levels of the foundation blocks should be measured by the concrete builder after finishing the work and a measurement report should be filed for possible remeasurements. The rails will be leveled during the installation.

Any critical foundation deviations can be corrected by installation of filler plates.

System specifications:

Temperature range:	-10 to 50°C
Safe Position:	The system is equipped with a rail clamp which can be used anywhere on the guide rails and protect the crane against undesired movements by strong winds. On one end (North or South) will be a safe position with fastenings for e.g. winter breaks.
Wind monitoring:	The wind speed is monitored continuously. If wind speed growth above a parameterized threshold, the rail clamps will be activated and protect the crane against undesired movements.
Payload:	The camerabox dimensions are approx. 3000mm x 3000mm x 1500mm (W x L x H), Weight approx. 2.000kg. The box will be weatherproof and the bottom can be covered automatically.
Electrical Power:	3x480V, 60Hz, Power approx. 30kVA
Electric supplies:	The system will have a 120V 60Hz circuit with plug-ins close to the main switchboard
UPS:	All computers will be secured against power drops by use of UPS.
Use of the system:	For 24h/7days a week automatic operation, day and night.
Remote Control:	The system can be operated in its 3 Axis by a wireless remote control
Automation:	The system is equipped with an industrial standard PLC and will be controlled by an Industrial standard PC.
Drives:	The Axis drives and the drive controllers are industrial standard and made for 24h/7days use.
Location:	The System is made for outside use in an agricultural environment.
Safety:	- The System will be equipped with a safety circuit. Emergency stop buttons will be located on different positions of the system.

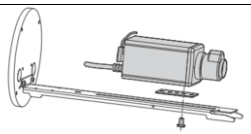
- Fencing around the operation field with a safety distance of at least 5m should be built by the customer. The fence gate will be protected with an electrical interlock guard locking. The gate can be opened only after pressing a button. After pressing this button the system will go in a paused state (after finishing measurements) and will release the door lock. After opening the door all Laser equipment is interlocked and the drives are in a safe mode.
- A laser safety light indicates the laser interlock states
- Laser warning signs should be arranged by the customer in front of the gate
- Guidance rollers to prevent the crane from sloping

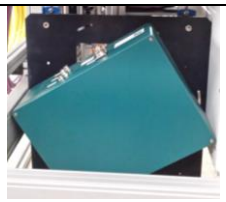
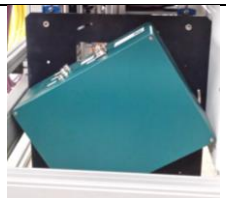
Signal lights:	Signal lights will be installed on top of the system to show the system conditions (e.g. Automation active, paused, pending errors, ...)
Electrical values:	Electrical values of the system will be monitored (e.g. line voltages, power consumptions, ...)
Thunderstorm:	A protection for thunderstorm damages should be considered by the customer (e.g. piles as lighting rods around the safe position)
Lighting:	Sufficient lighting will be installed to allow maintenance work even without sunlight.
Axis positions:	- All 3 Axis positions will be measured by absolute value devices. Those devices will measure the absolute position with an accuracy of +-2mm. This accuracy is different from the positioning accuracy which depends on the positioning speed and drives hardware. X-Axis: 2 absolute value devices were used on each guiding rail. Therefore a barcode will be fixed to each rail and the drives of both sides of the system will be positioned independently on the required position. This guarantees a smooth movement of the axis by preventing slope. Y-Axis: 1 absolute value devices will be installed. The same positioning system as on the x-Axis will be used. Z-Axis: 1 absolute value device will be installed. It will be a cable sensor which is winded and unwinded.
Rail level:	The guide rails will be mounted in a height of minimum 200mm above soil level
Access:	There will be a ladder on one pile of the system and a gangway parallel to the cross beam and Y-Axis in 8m height will be installed to give access to the main switchboard at the side of the system and the switchboards and drives on top of the Z-Axis in each position.
Switchboards:	All switchboards will be designed for outside use and will be air conditioned appropriately. The main switchboard will be installed in a 15ft container which will be mounted to the east side of the system. It will be isolated against outside temperatures and air conditioned. There will be 5 switchboards installed with the system: Switchboard S0 located on the north-east side of the system, close to the bases. This switchboard contains the connection interface between customer and LemnaTec for electricity and data line. Switchboard S1 as the main switchboard inside the 15ft container at the side of the system. The main switch and all maintenance switches will be installed here as well as the PLC, the control computer and the X-Axis drive controllers. Switchboard S2 on top of the Z-Axis containing the drive controllers for the Y- and the Z-Axis Switchboard S3 mounted at the camera box containing power supplies and IT-infrastructure for the cameras and sensors inside.

	Switchboard S4 at the west side of the system containing power supplies and IT-infrastructure for the cameras mounted on the west-side of the system
Side looking sensors:	There will be 2 C-Rails installed on each of the 4 vertical piles for camera installation. The C-rails allow a continuously positioning of the sensors between rail level and 8m height.
Operation Modes:	Different operation modes can be switched on or off by using key-locked switches. Automatic mode Lasers safe Maintenance mode
Electrical Standard:	The system is build following CE-Standards. (Some of the electrical components are UL listed.)
Colors:	Sides: RAL6018 Cross beam: RAL5017 Camerabox: RAL~~1013~~ 9016 Traffic white
LemnaTec sign:	Inside the crossbeam on both sides (North and South)
Delivery:	Incoterm DAP (Delivered at place)

Cameras and sensors

Overview

Amount	Description	Pictures	Camera	Technical Data
1	HYPERSPECTRAL IMAGER #1: 380-1000 NM		Inspector VNIR	Spectral range: 380 – 1000nm
1	HYPERSPECTRAL IMAGER #2: 900-2500 NM		Inspector SWIR	Spectral range: 900-2500nm
0 (Optional)	(OPTJONAL) HYPERSPECTRAL IMAGER #3: 550-1700 NM		Inspector XVNIR	Spectral range: 550nm-1700nm
2	THERMAL INFRARED (IR) WITH 640x480 ON GREATER RESOLUTION AND AT LEAST 25 HZ IMAGE FREQUENCY AT FULL RESOLUTiON		FLIR SC615	Resolution: 640 x 480px Thermal sensitivity: <50mK @ +30°C Object temperature range: -40°C to +150°C Frequency: 50Hz Lens: 25° x 19° Focus: Automatic
1	DEDiCATED NDVI SENSOR (2 Sensors, 1 down and 1 uplooking)		NDVI Sensors Skye	Centre Wavelength CH1: 650nm +-3nm Centre Wavelength CH2: 800nm +-3nm Bandwidth: 40nm +-3nm
1	DEDICATED PRI SENSOR (2 Sensors, 1 down and 1 uplooking)		PRI Sensors Skye	Centre Wavelength CH1: 531nm +-3nm Centre Wavelength CH2: 570nm +-3nm Bandwidth: 10nm +-3nm
1	PAR Sensor		Quantum	Spectral Range: 410nm to 655nm Measurement Repeatability: <1% Field of View: 180°
1	Color Sensor		STS-VIS	Spectral range: 350 – 800nm Integration Time: 10µs – 10s Signal-to-Noise Ratio: >1500:1 (maximum Signal)

1	TDP—DOWN HEIGHT SCANNER SYSTEM (1 System consists of 2 scanners)		3D Fraunhofer (1 System)	Minimal Measurement Distance: 2m Measurement width: 0,55m – 0,95m Scan depth: 1,5m Scan resolution: 0,3 – 0,85mm Scan resolution (right angle to scan dir): 0,3 – 0,5mm Scan frequency (max): 700Hz Laser Wavelength: 800nm Laser Power: 2000mW Laser class: 3B
2	SIDE-LOOKING LASER SCANNERS (1 System consists of 2 scanners) Optional mountings for Laser Scanners on each of the 4 gantry columns		3D Fraunhofer (2 Systems)	Minimal Measurement Distance: 3m Measurement width: 0,85m – 1,25m Scan depth: 1,5m Scan resolution: 0,6 – 1,3mm Scan resolution (right angle to scan dir): 0,45 – 0,65mm Scan frequency (max): 700Hz Laser Wavelength: 800nm Laser Power: 2000mW Laser class: 3B
2	8+ MP RGB CAMERA SYSTEMS 1 DOWNWARD LOOKING		GT3300C	Resolution: 3296 x 2472px Sensor size: Type 4/3 Bit depth: 14bit (mono)/ 12bit (color) Frame rate at full resolution: 14,7fps
4	2 SIDE LOOKING RGB AT DIFFERENT Heights		GT3300C	Resolution: 3296 x 2472px Sensor size: Type 4/3 Bit depth: 14bit (mono)/ 12bit (color) Frame rate at full resolution: 14,7fps
1	ACTIVE REFLECTANCE IN-FIELD SENSOR SUCH AS CROPCIRCLE AC5-4x0 on GREENSEEKER SYSTEM PROVIDING DAY-NIGHT OPERATION		ACS430P Crop Circle	Measurement channels: 670nm, 730nm, 780nm Measurement range: 0,25m – 2,0m Field of View: 40~45° x 6~10°
1	FLUORESCENCE MEASUREMENT SYSTEM		PSII Camera LemnaTec	Field of View: >0,25m^2 Resolution: >= 1MP Frame Rate: >= 20fps Light intensity: >4000µmol/m^2/s Wave length: 635nm

1	ENVIRONMENTAL SENSORS - RAINFALL, TEMP, HUMIDITY, LIGHT INTENSITY)		Thies Clima (Environmental)	Wind: 0 - 60m/s, Resolution: 0,1m/s Wind direction: 0 – 360°, Resolution: 1° Air temperature: -30°C – 70°C, Resolution: 0,01K Rel. Humidity: 0 – 100%, Resolution: 0,1% Air pressure: 300 – 1100hPa, Resolution: 0,01hPa Lightness: 0 – 150kLux, Resolution: 30Lux Precipitation: 0 – 10mm/min, Resolution: 0,01mm
1	$C0^2$ Sensor		GMP343	Measurement range: 0 – 1000ppm, Accuracy: <+-1%
1	ACCOMMODATION FOR ADDITIONAL EXPERIMENTAL SENSORS (AFTER INITIAL DEPLOYMENT)			Dedicated Space: 1560mm x 303mm x 1200mm (L x W x H), Weight: 25kg Electrical Power: 480V AC/24V DC/12V DC (more voltages can be added on demand) Data Connections: Ethernet, analog and digital signals

LemnaTec

Network Topology

The following schematic gives an overview of the network topology of the system. It is structured by system components and major switchboards. Please note that the topology is in a design phase and subject for change.

The optical fiber between customer infrastructure and system interface will be defined and have to be agreed.

System Layout

The following drawing shows the main dimensions of the gantry crane, the field size and gives a brief overview of the foundation layout.
The main dimensions of the system are fixed (rail distance, rail length, system height, payload of camera box).

Camerabox

The camerabox design is almost fixed and seen in the following drawing. The sensor positions are flexible by use of a aluminum profile system for precise adjustment during start-up.
The camerabox is covered by a weather proof housing preventing rain intrusion. The bottom can be covered by a flap in case of heavy weather or in case of longer operational breaks.
To prevent accumulated heat inside the camerabox 4 powerful fans will be installed with a flow of 180m^3/hour each into the weather proof housing.
For the cameras a cooling system will be installed and the camera housings will be tempered individually.

Several maintenance spaces to reach the camera housings are considered in the camerabox designed and marked as red rectangle in the drawing.
Spare space for additional sensor is marked with green hatches in the drawing.
The camerabox is connected to 270V AC power. Several different AC and DC voltages for additional sensors can be provided by use of power supplies.
Fo**Figure 7: Construction layout foundations and gantry crane**
which are part of the basic topology.

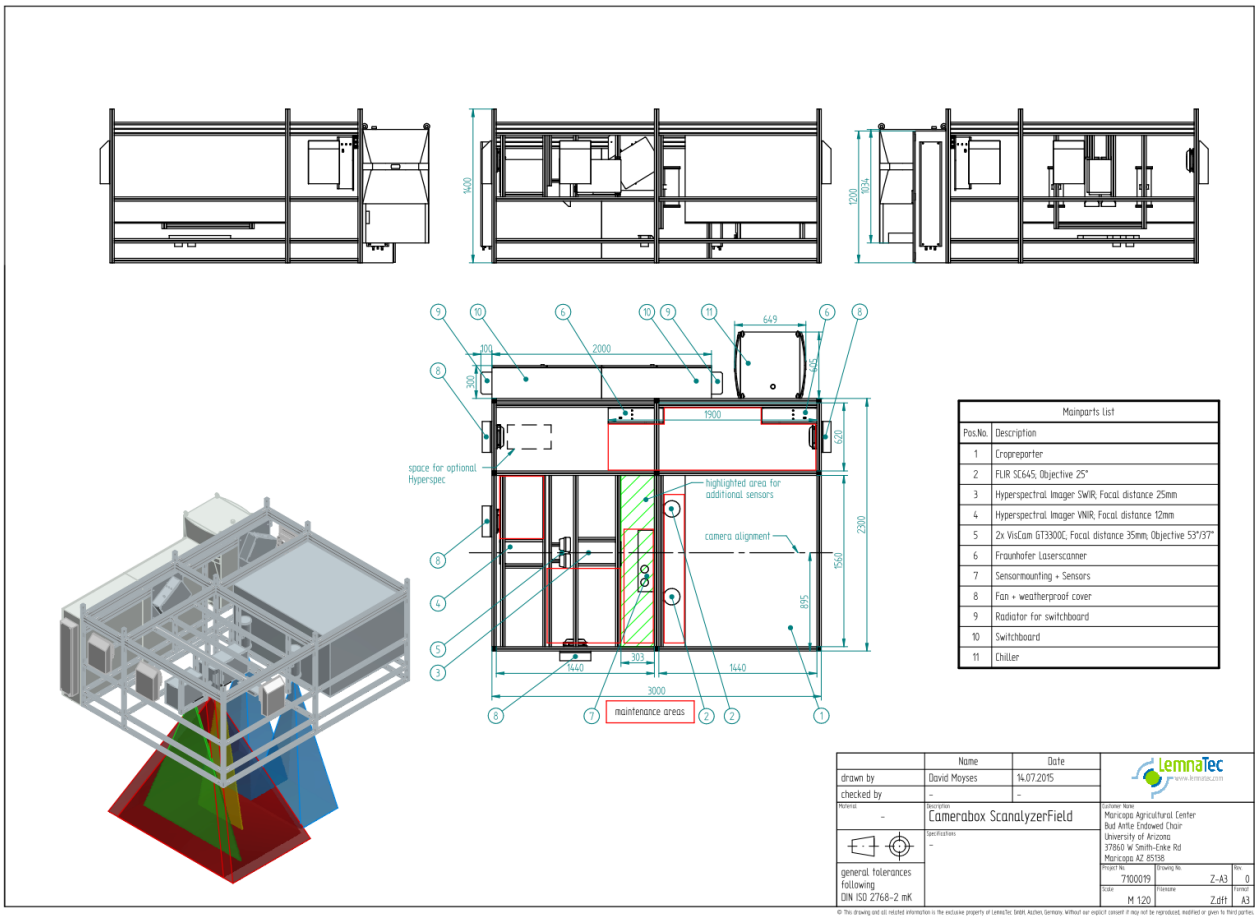


Figure 8: Draft drawing of Camerabox, Version July 14th 2015

Side looking Sensors

There are two kinds of site looking sensors, for installation on the gantry columns.

1. 3D-Scanners: 2 side looking 3D-Scanners will be installed on vertical C-rails mounted on each of the 4 gantry columns. The sensors can be moved in height between approx. 1m and 8m above ground. The 3D-Scanners can be installed either on the Eastern or Western gantry columns.
2. RGB Cameras: 4 RGB Cameras can be installed on each of the 4 gantry columns. The sensors can be moved in height between approx. 1m and 8m above ground.

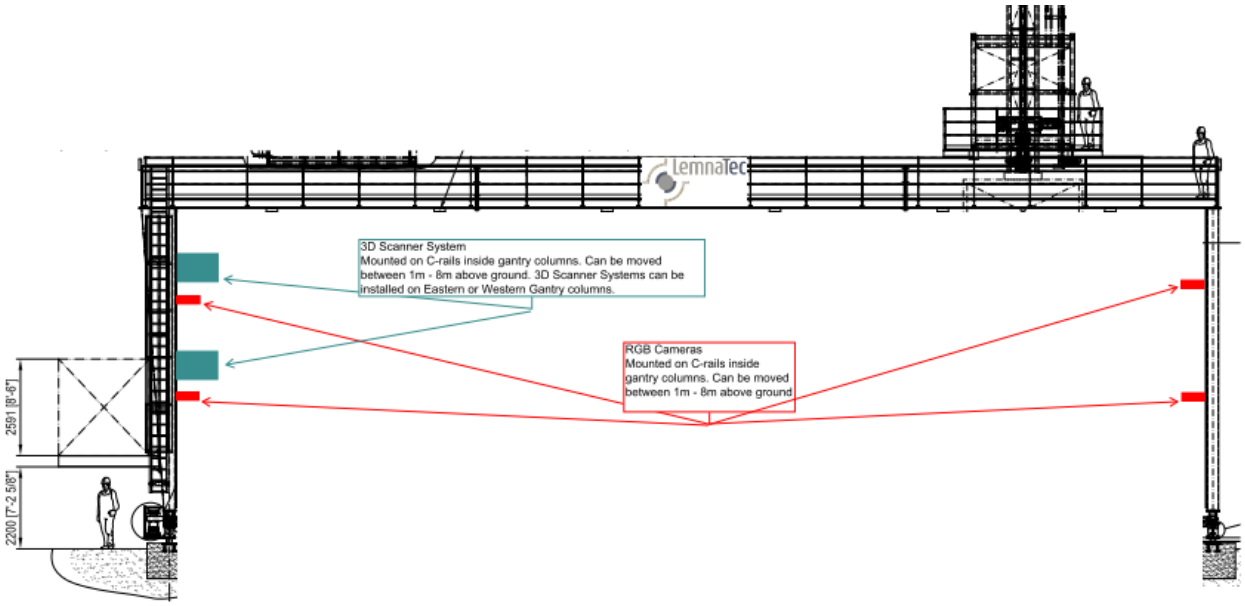


Figure 9: Side looking cameras can be installed on each of the 4 gantry columns

Camera Modes

Are in development and will be added in next Version.

Functions

Operational Modes

The system is designed for automatic field phenotyping, controlled by customized software without manual influence after initial parameterization.

For start-up, troubleshooting and maintenance a manual mode is implemented allowing the control of the gantry crane axes by use of a remote control and other functions by a PLC interface.

For technical support from LemnaTec a working VPN connection to the system is required allowing full control for troubleshooting, training or general support.

User Interfaces

There a several interfaces for operators and users of the system:

1. Control PC: The control PC is the main user interface. The LemnaTec software provides all functions for parameterization and configuration of experiments.
2. PLC Display: Provides the full functionality of hardware functions and parameters used for troubleshooting and maintenance.
3. Remote control: Allows controlling the crane axes by manual functions for troubleshooting, maintenance and teaching of the system.
4. VPN Connection: Allows remote control for LemnaTec support team in case of technical issues, trainings or other support tasks.

Deliverables

1. System Design
    a. System Layout
        i. Location for Connection points Electric/Data
    b. Construction Drawings
        i. Gantry Crane
        ii. Camera Box
        iii. Foundation design for concrete works
        iv. Rails
    c. Electrical Diagram
    d. IT equipment
        i. PLC
        ii. Control PC
        iii. Switches and Ethernet infrastructure to the interface inside switchboard S0
2. Manufacturing and assembling
    a. Pre-Acceptance Test at builders site for main components
3. Delivery
    a. Packing and container stuffing
    b. Shipment
4. Installation and start-up
    a. Crane rails on customers concrete foundations
    b. Crane parts
    c. Cameras and sensors
    d. Long-Term test (100h)
5. Software
    a. System software on PLC and IPC
    b. Software Licenses
6. Documentation
    a. System operations manuals
    b. Monthly project reports
7. Training
    a. Operator
    b. Maintenance
    c. Safety
    d. Application

Customer's providing's:

1. Electrical Power
    a. 480V 60Hz 50kVA (Preliminary Values)
2. Data Connection
    a. Optical fibre, 10GB/s to be defined, to the interface inside switchboard S0
    b. VPN access to system control computer
3. Database infrastructure
    a. Database space with fast connection for data storage
4. Concrete Foundations
    a. Soil and ground survey
    b. Concrete foundations (According to plans provided by LemnaTec)
        i. Concrete foundations measurement protocol after finishing
5. Storage space
    a. Fenced and secured against trespassing and theft
    b. For at least 10 4ft containers
    c. Air conditioned room for camera storage and assembly
6. Installation
    a. Layout with exact position and orientation of the system
    b. Access to the field for installation equipment (e.g. heavy forklifts, mobile cranes,...) (Dimensions and weights of installation equipment will be provided later)
    c. Electricity for installation tools
    d. A flat trailer for installation of the camerabox
7. Safety
    a. Fencing around field system
        i. Lockable door
    b. Lightning rods

Attachments

1. System layout
2. Camera box drawing

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Fax +49 2408 9383 300

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