3D Sensor featuring Cognex Designer Standard

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Course Agenda (day 1)

1. 3D Hardware
2. Designer Software
3. Acquiring Images
4. Create a User Interface
5. 3D Tools

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This class will teach you how to connect, control, and inspect your parts with the 3D Displacement Sensor.

We'll start with just getting the system up and running, move to capturing an image, set up some tools, extract results, and create a simple, yet functional user interface.

Let's get started.

Course Agenda (day 2)

6. More 3D Tools
7. User Interface – part 2
8. I/O and Network Communication
9. Deploying an application
10. Saving Images

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We'll start with just getting the system up and running, move to capturing an image, set up some tools, extract results, and create a simple, yet functional user interface.

Let's get started.

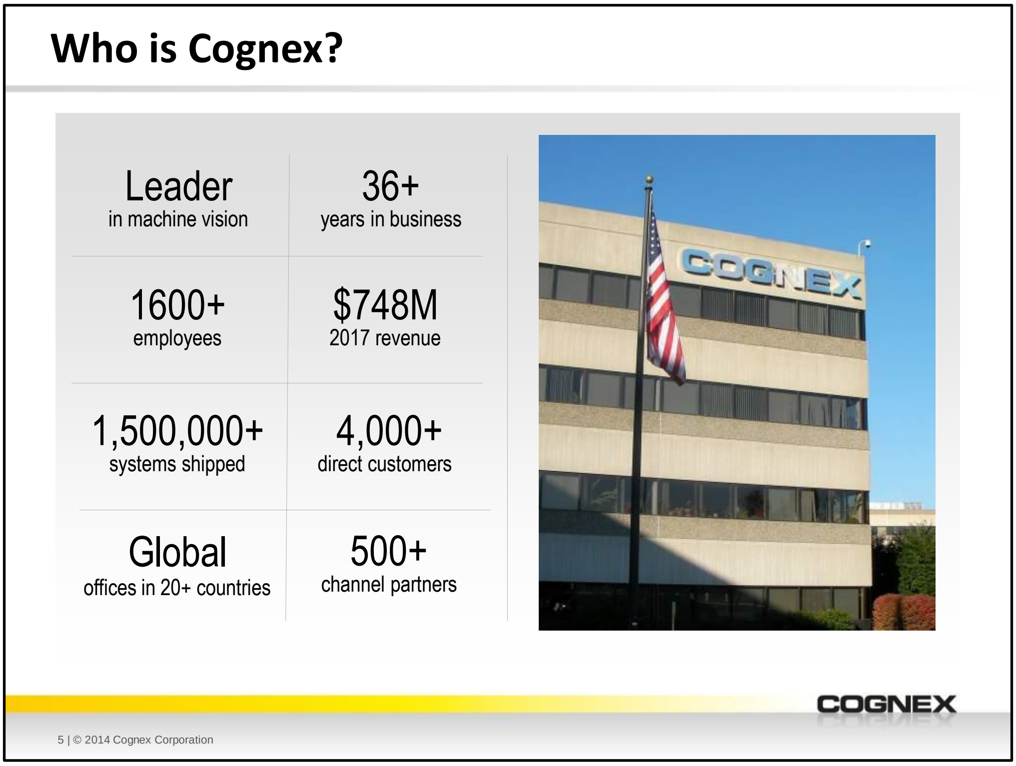
Introductions

- Your Name
- Company
- Location
- Your Role
- Vision Experience
- Expectations for Class

We thank you for coming to see us and allowing us to help you get the most from your Cognex products.

We'd like to get to know you and what's important to you.

Please share as much as you can. Even if a topic is not scheduled as part of this class, please ask us about it, and we'll do our best to make it part of the class for you.



Cognex has been in business since 1981--we were one of the first machine vision companies to get started when industrial vision was just emerging from academic laboratories.

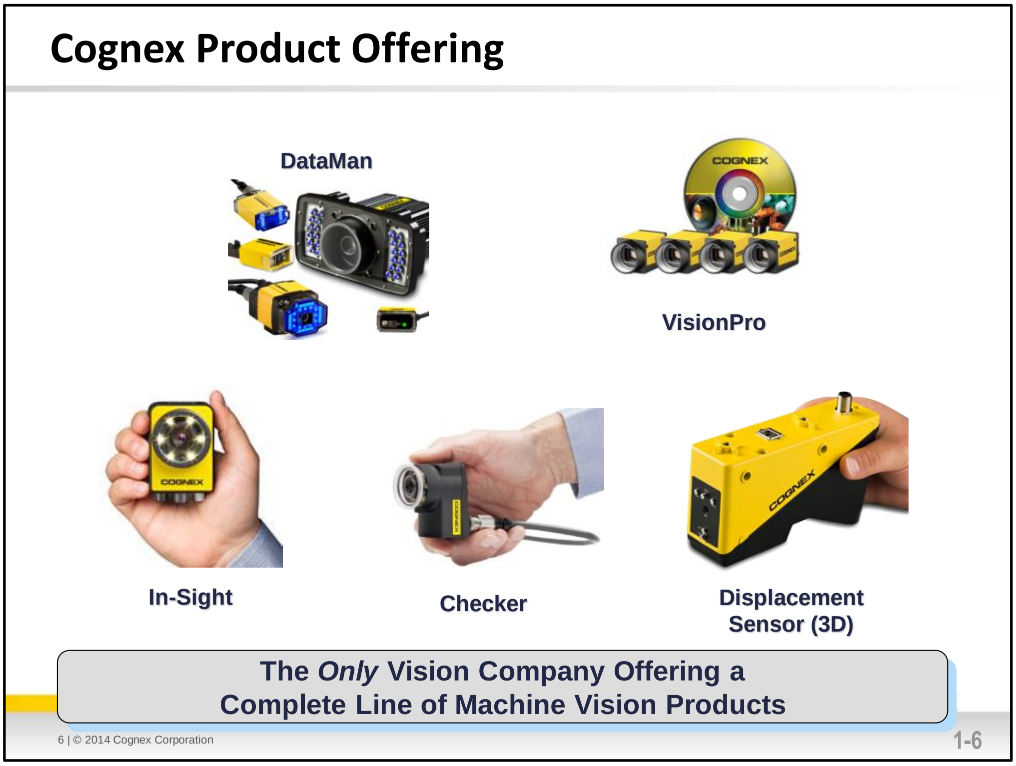
Our engineers pioneered some of the earliest commercial applications for machine vision. Many vision tools that are now commonly used in the industry were the brainchild of our co-founder, Bill Silver, an MIT graduate who is recognized as one of the world's leading experts in machine vision.

We have nearly 30 years of experience developing machine vision solutions in almost every application where vision is currently used.

We have more than 1,000,000 installations….which have given us experience in a lot of different kinds of application.

Cognex also has a global presence, so we are able to support you anywhere in the world with local representatives for training and support.

Cognex serves an international customer base from offices located throughout North America, Europe, Japan, Asia and Latin America, and through a global network of integration and distribution partners. The company is headquartered just outside Boston in Natick, Massachusetts, USA.



Cognex offers a complete range of machine vision products:

- **DataMan** products focus on decoding marks like barcodes and DataMatrix at very fast speeds.
- **VisionPro** applications run on a PC and take advantage of their speed and processing power on multi-camera applications.
- **In-Sight** systems are smart cameras that take care of image acquisition and image analysis all in one tightly integrated packaged.
- **Checker** takes care of simple applications that would normally require multiple photo sensors.
- **Displacement Sensors** perform 3D inspections that allow you to extract and analyze features best seen using 3D space.

Section 1: 3D Hardware and Image Acquisition

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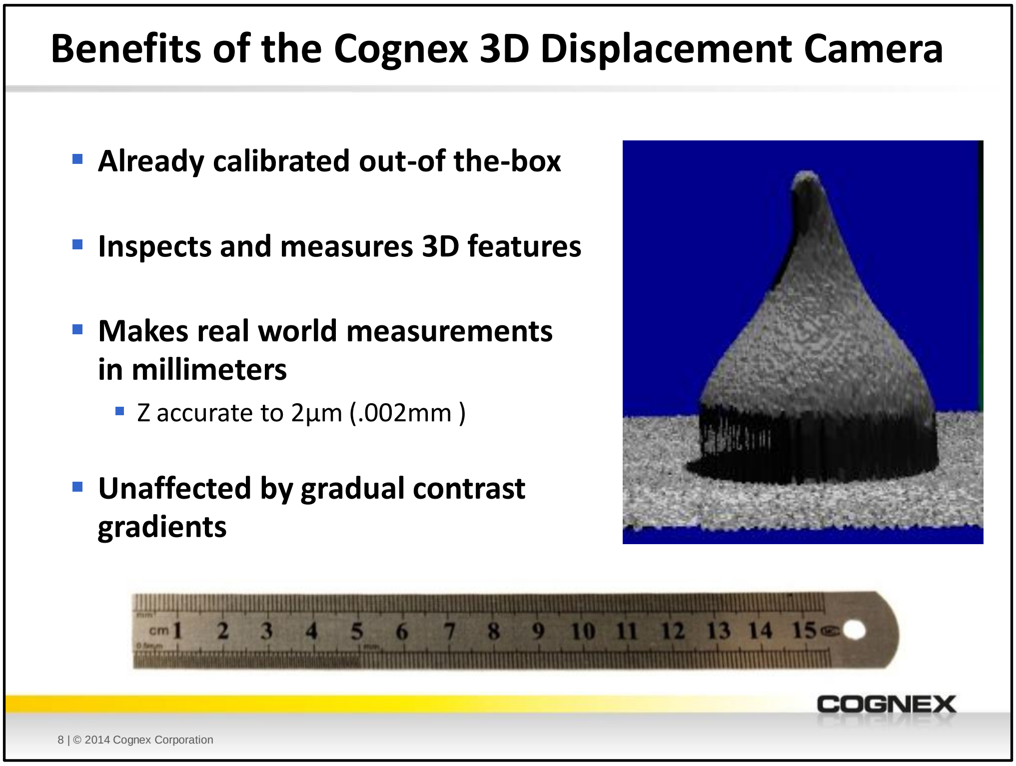
Leo Dreyfus / Cognex

Right now we’re going to talk about:
- the camera hardware
- How 3d imaging works
-

This section will introduce you to two very simple, yet critical components.
Getting connected and getting a good image (often overlooked).

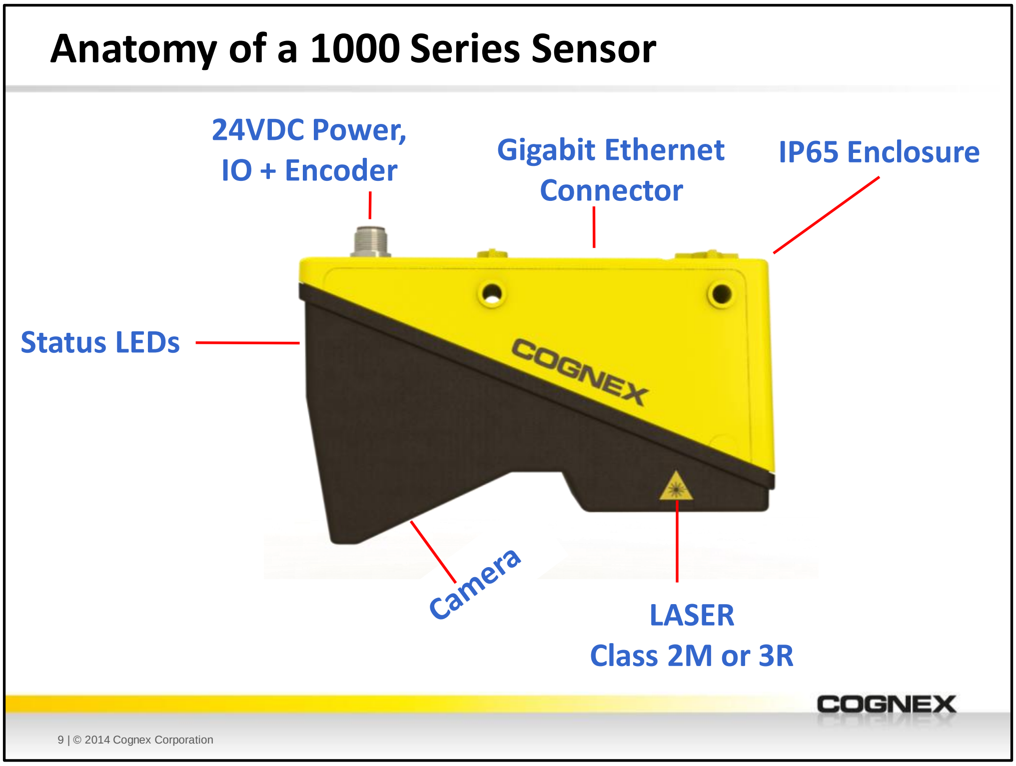


Cognex DS1100™ Series is an integrated digital camera and LASER stripe illuminator, mounted in a single mechanically robust package. DS1100 uses two-dimensional surface profiling to create three-dimensional range images from those profiles.

DS1100 offers the following advanced features:
- highly accurate physical object measurements
- high-speed operation
- flexible mounting options

DS1100 works by analyzing the shape of the LASER stripe as it appears to the camera (which is positioned at an angle to the LASER). The software running in the device can determine the 3D location of the points through which the LASER stripe passes.

DS1100 acquires several of these images while the scene in front of the sensor is moving, and by stitching them together, provides a 3D height image of the inspected object.



Ethernet Link Status - This LED indicates what type of link the device has achieved with the host.

If the LED is off, no link has been achieved. If you see blinking in groups of 3 (blink-blink-blink-pause-blink-blink-blink-pause, and so on), a 1000 Mb (GigE) connection is established.

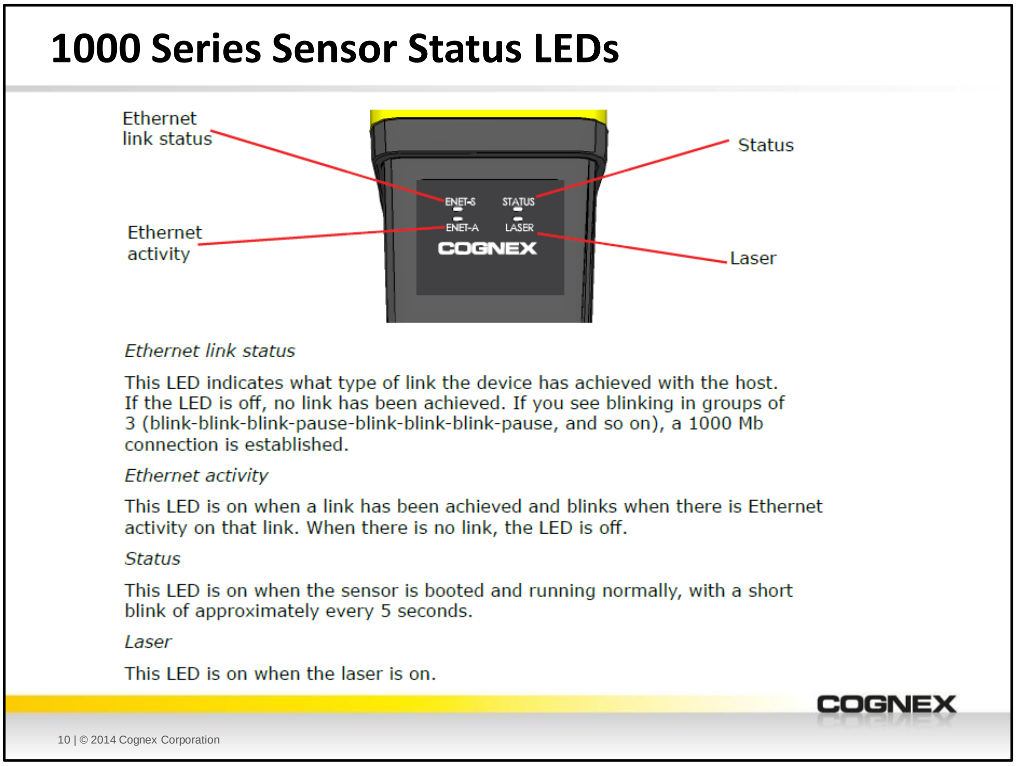
Ethernet Activity - This LED is on when a link has been achieved.

It blinks when there is Ethernet activity on that link. When there is no link, the LED is off.

Status - This LED is on when the camera is booted and running normally

It has a short blink of approximately every 5 seconds.

LASER - This LED is on when the LASER is on.



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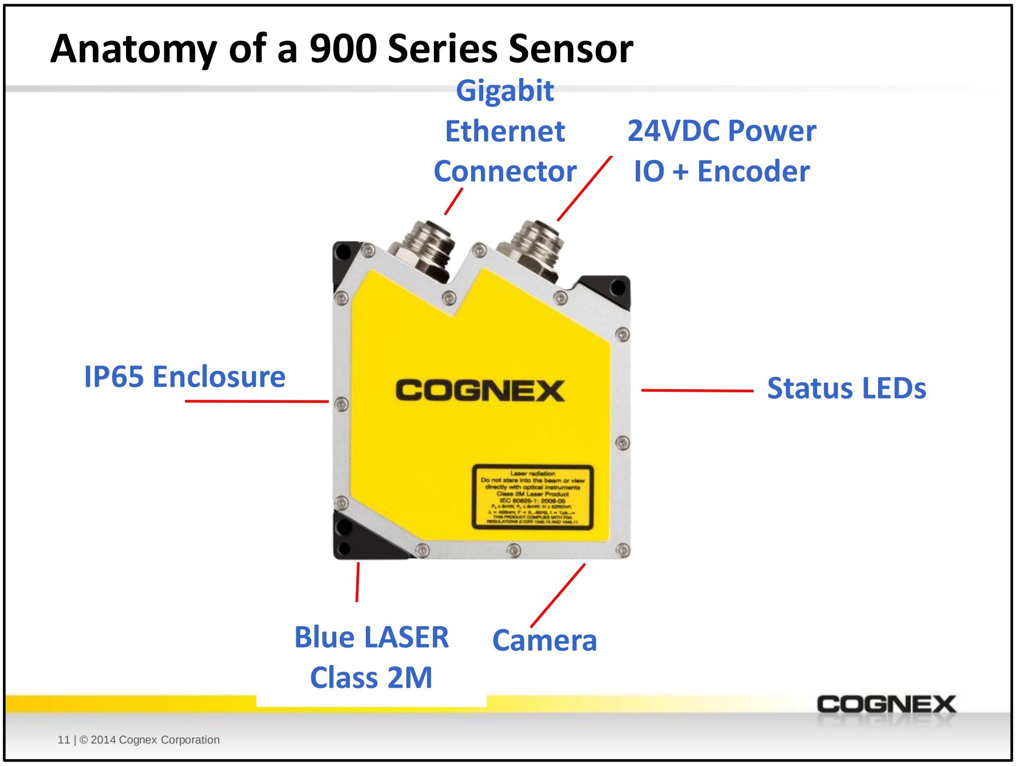

Compact form factor
- 85mm x 96mm x 33mm
- Compared to DS1000 series
  - 52% reduction in length
  - 16% reduction in height
  - 36% reduction in width

Blue laser (405nm)
- Tight beam waist, high resolution
  - 2 µm resolution in Z
  - 20 µm resolution in X

Overall advantages
- Fits into tight spaces and easily mounts to robots
- Enables high accuracy measurements on small parts

DS925B/1000 Series Models and Specs

	DS925B 	DS1050 	DS1101 	DS1300 
Near Field of View	23.4 mm	43 mm	64 mm	90 mm
Far Field of View	29.1 mm	79 mm	162 mm	410 mm
Clearance Distance (CD)	53.5 mm	87 mm	135 mm	180 mm
Measurement Range (MR)	25 mm	76 mm	220 mm	725 mm
Resolution, X-axis	18.3 µm – 22.7 µm	59 µm – 90 µm	79 µm – 181 µm	101 µm – 457 µm
Resolution, Z-axis	2 µm	4 µm – 14 µm	10 µm – 52 µm	16 µm – 265 µm
Max scan speed	1.2 kHz	10 kHz	10 kHz	10 kHz
Laser color and class	Blue @405nm Class 2M (8mW)	Red @658nm Class 2M Red @660nm Class 3R	Red @658nm Class 2M Red @660nm Class 3R	Red @660nm Class 3R
Size (mm)	85 x 96 x 33	176.5 x 113.7 x 51.5	176.5 x 113.7 x 51.5	176.5 x 113.7 x 51.5

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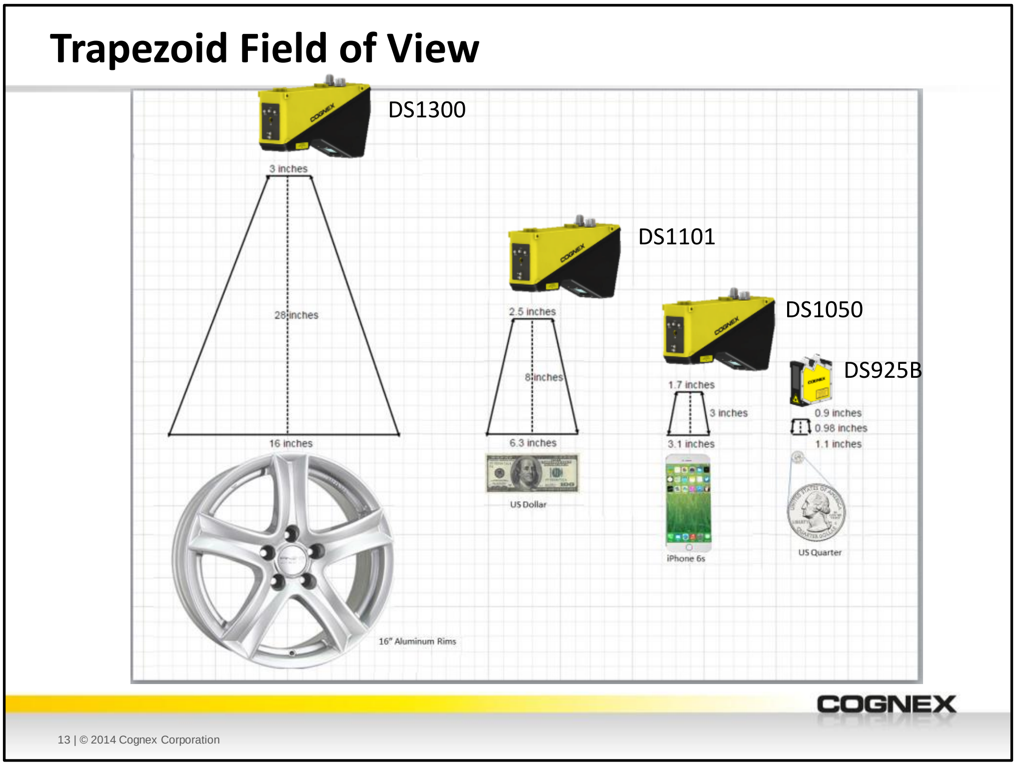
Lasers:
Class 2M is < 1mW
Class 3R is < 5mW

1µm = 1 millionth of 1 meter (.001mm)
25.4 µm = 1/1000 inch, commonly referred to as 1mil in the U.S.

Size examples:
7 µm — diameter of human red blood cells
9 µm — thickness of the tape in a 120-minutecompact cassette
17 µm — minimum width of a strand of human hair
25.4 µm — 1/1000 inch, commonly referred to as 1 mil in the U.S.
70 - 180 µm — thickness of paper



This represents the approximate size of the trapezoid of vision through which the camera looks. What is not seen here, but is listed on the previous page, is the distance between the camera and the top of the trapezoid.

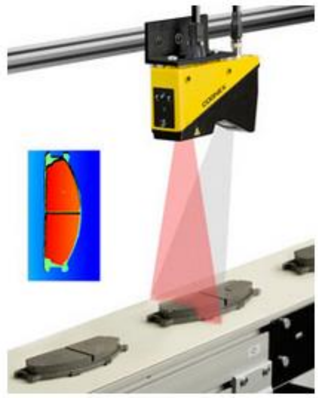
What You'll Need

Hardware

- **Displacement Sensor Camera**
- **Encoder**
- **Power Supply**
- **Cat 6 Ethernet Cable**
- **Compatible Cognex Hardware**
  - **VC5 Vision Controller**
  - **CC24 I/O Card**
  - **8704 Frame Grabber**

Software

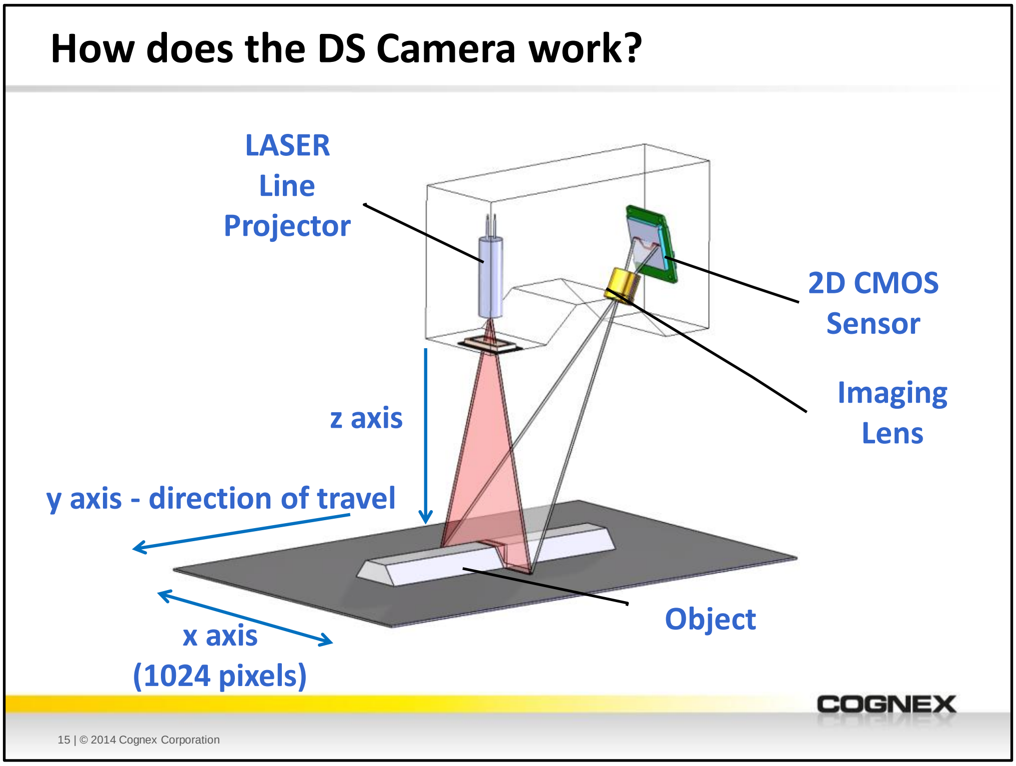
- **Cognex Designer**
- **VisionPro (required plug-in)**



This is just a short list of the items that we'll need to get started, but these will help us get up and running.

It's important to have a mounting setup that allows us to consistently move the part under the sensor or move the sensor over the part.

Cat5 – certified to 100Mbps
Cat5e – up to 1,000Mbps @ 100MHz
Cat6 – 1,000Mbps ->10,000Mbps @ 250MHz



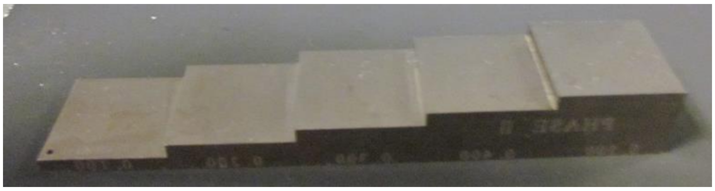
A Cognex DS1101™ 3D Sensor (referred to as DS1101) can return information about the 3D shape or size of objects that are difficult to visualize using regular 2D cameras. From a DS1100 sensor, the VisionPro acquisition system can acquire Intensity images and Range images that can be used to determine the height profile of objects passing under the DS1100 sensor.

The following overview illustrates how DS1101 works with a typical application.

1. Place the object you want to measure on a conveyor belt equipped with an encoder.
2. As the object passes under the DS1100, it acquires a series of images (Intensity images).
3. In each acquired image, the camera locates and measures the position of the apparent LASER line (the brightest pixels). DS1100 then transforms each intensity image into the corresponding rows of the range image

How the DS 1100 ™ Series 3D Sensor sees the world

- **The grayscale intensity represents the mm height value**



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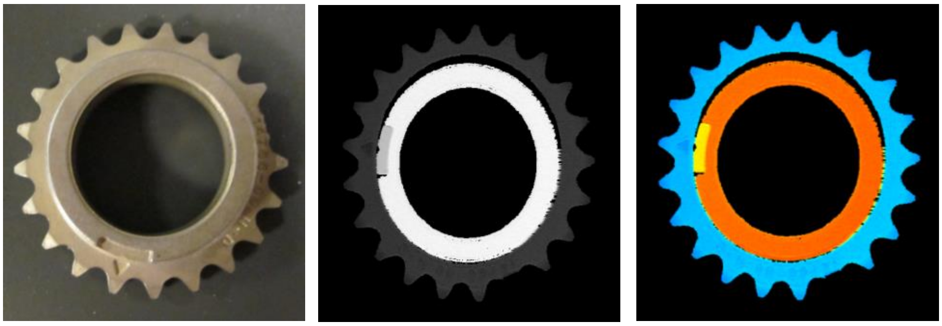
A range image is a 16-bit grayscale image containing height profile information in millimeters. It is generated from a series of acquired intensity images. Each row of the range image corresponds to one intensity image. A row of the range image is generated by expressing the calibrated peak data obtained from the intensity image in grayscale pixel values.

These images are then assembled and the whole picture of the object passing under the LASER is created. This is called a **range image.** Calibration transforms the raw peak data into real world coordinates and thereby also removes distortions such as camera lens distortion and perspective distortion.

How the DS 1100 ™ Series 3D Sensor sees the world

- **Generates a 16bit 3D range image**



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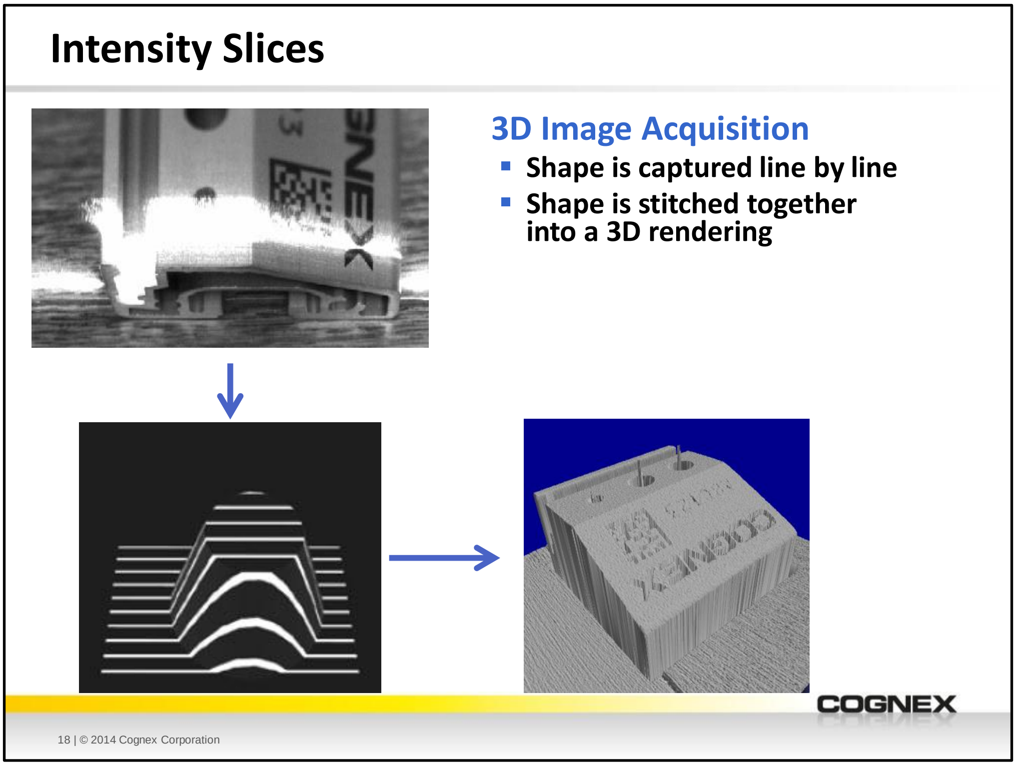
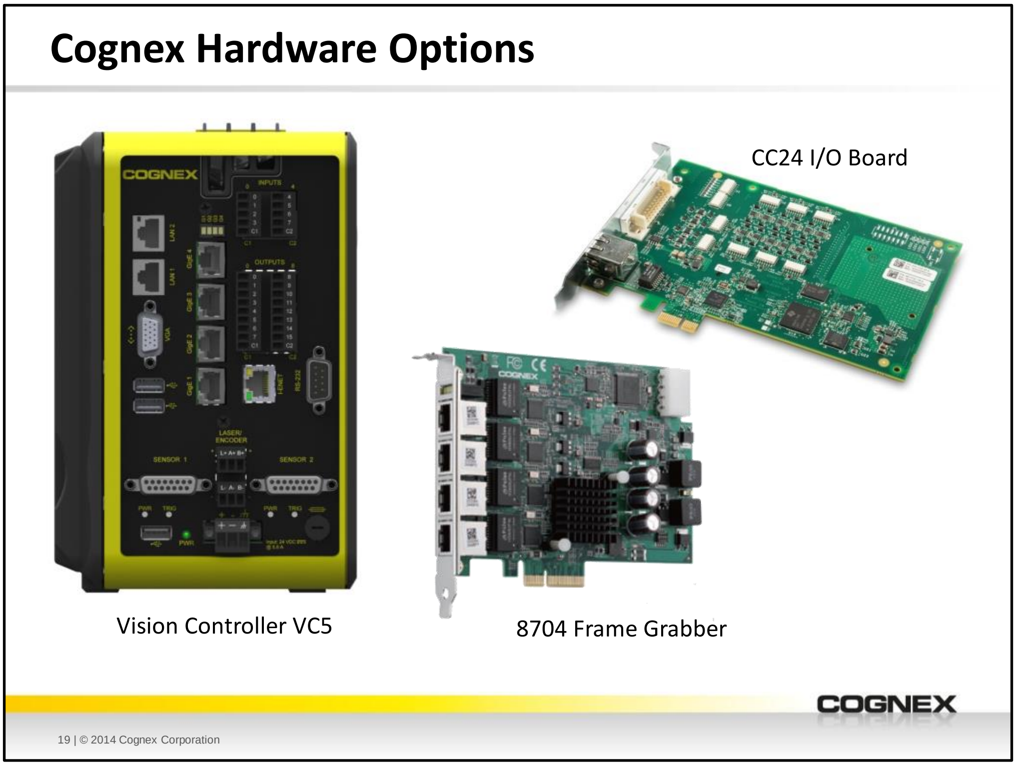
A 16 bit image can handle 65,535 discrete levels of information instead of the 256 levels that an 8 bit image can.

Color Mapping can be used to visually identify the different heights associated with the image.



With each encoder tick as the camera or part moves past the DS 1100 an intensity slice is taken and transformed into the range image.
Each acquired intensity image of a LASER stripe is the basis of a single row in the range image.

The range image in the diagram above has been generated using more LASER stripes than shown above, hence the range image has more rows than the number of the shown LASER stripes. Reduced number of LASER stripes are shown to illustrate the process in a clearer manner. We will describe the creation of this range image in a moment.



Access to Cognex Designer will be controlled by hardware.

Hardware Required

- VC5 Vision Controller
- CC24 I/O Board
- 8704 Frame Grabber

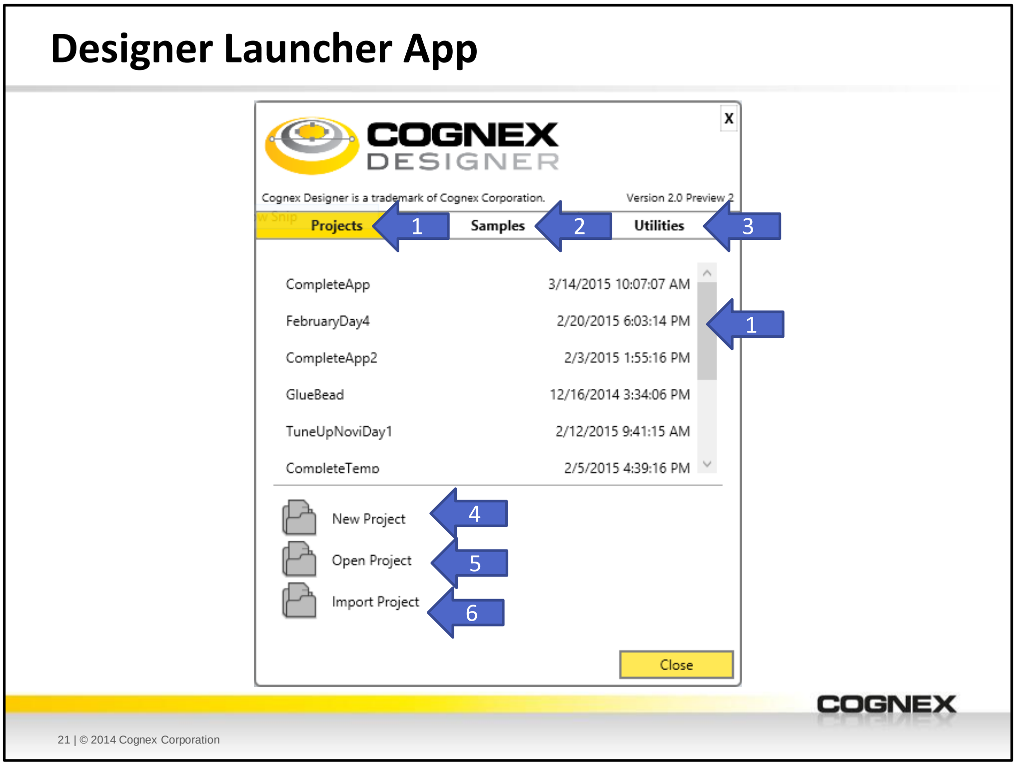
Launching the Software

Designer
Application
Icon

To launch Cognex Designer:

- Use the shortcut installed on your Windows desktop
- Launch it from the Windows installed applications

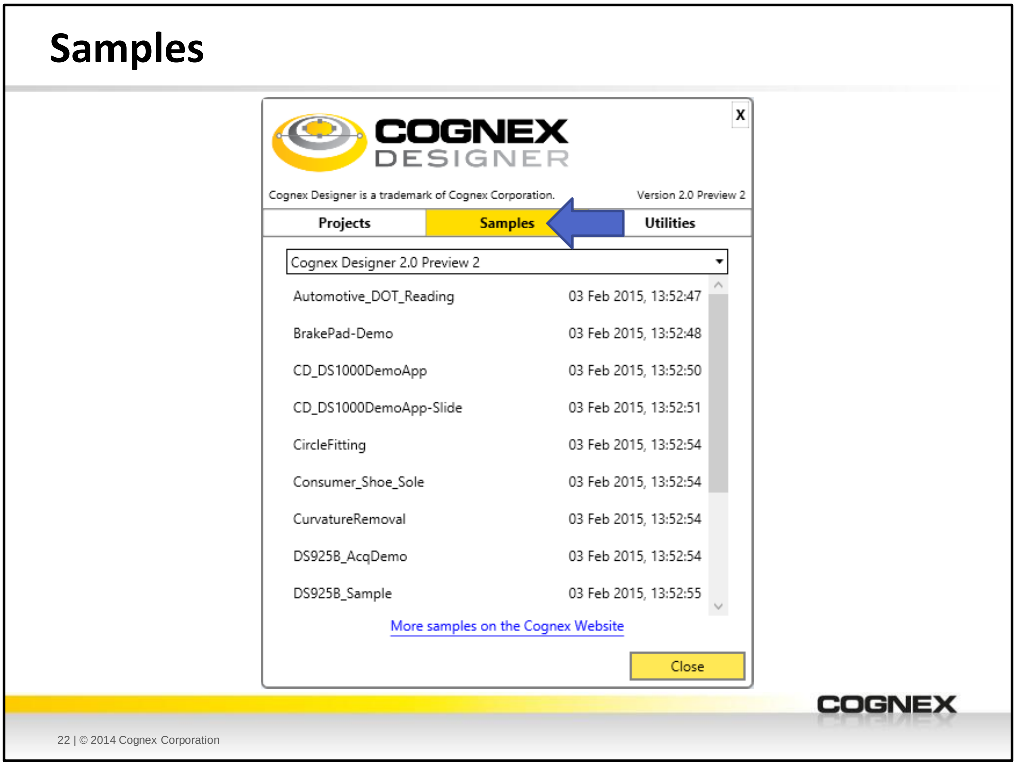
Even though VisionPro software must also be installed, you will not launch it directly. It serves as a plugin Cognex Designer will use.



When Cognex Designer launches, you can:

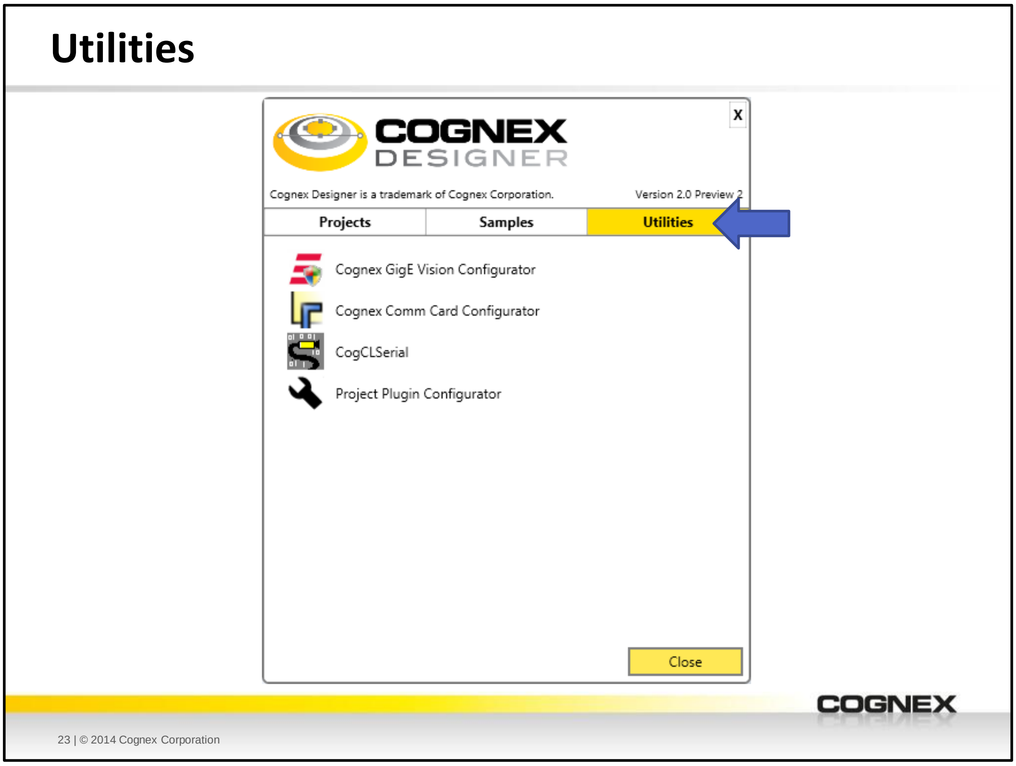
1. Access a list of frequently used projects
2. Access a list of sample projects
3. Access configuration utilities
4. Create a new project
5. Open an existing project by navigating the PC's hard drive disk (HDD)
6. Import a previous version of a project

Pro tip: There is a Recent.lst file found in the default projects directory (…\Documents\Cognex Designer\Projects) that holds the names of the created project files. Names can be removed on this list (via Notepad) if you do not want it listed in the Projects list of Cognex Designer.



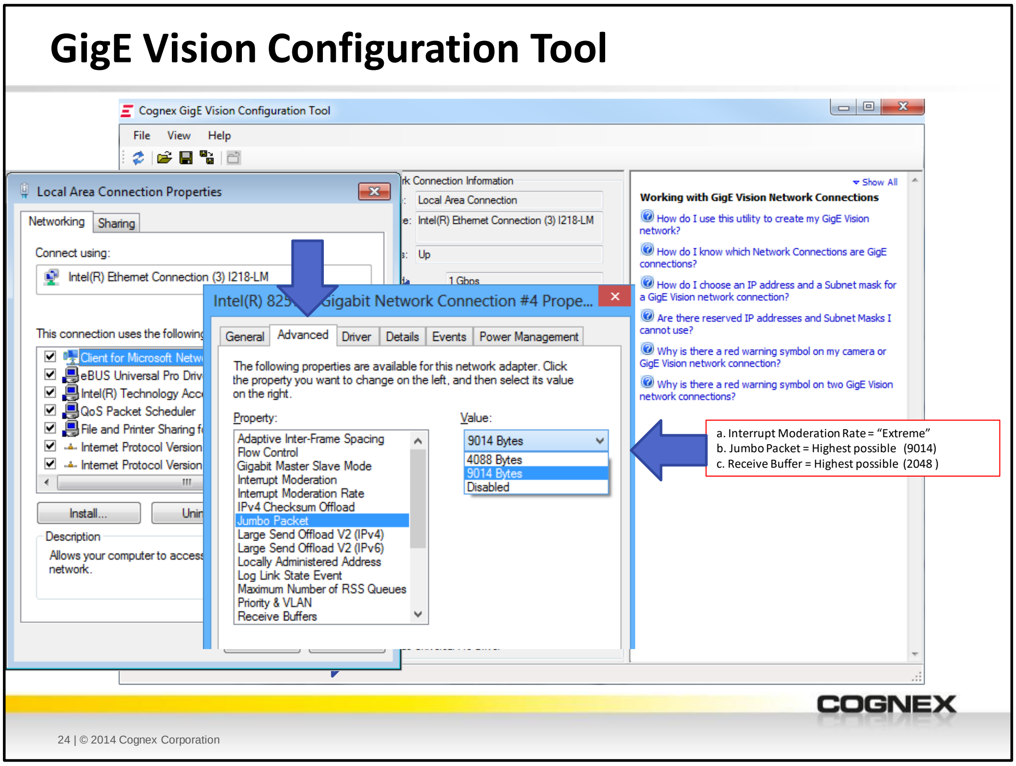
Only one sample is included when the current version of the software is installed.

You can obtain additional samples at training classes or at **http://www.cognex.com/support/cognex-designer/.**

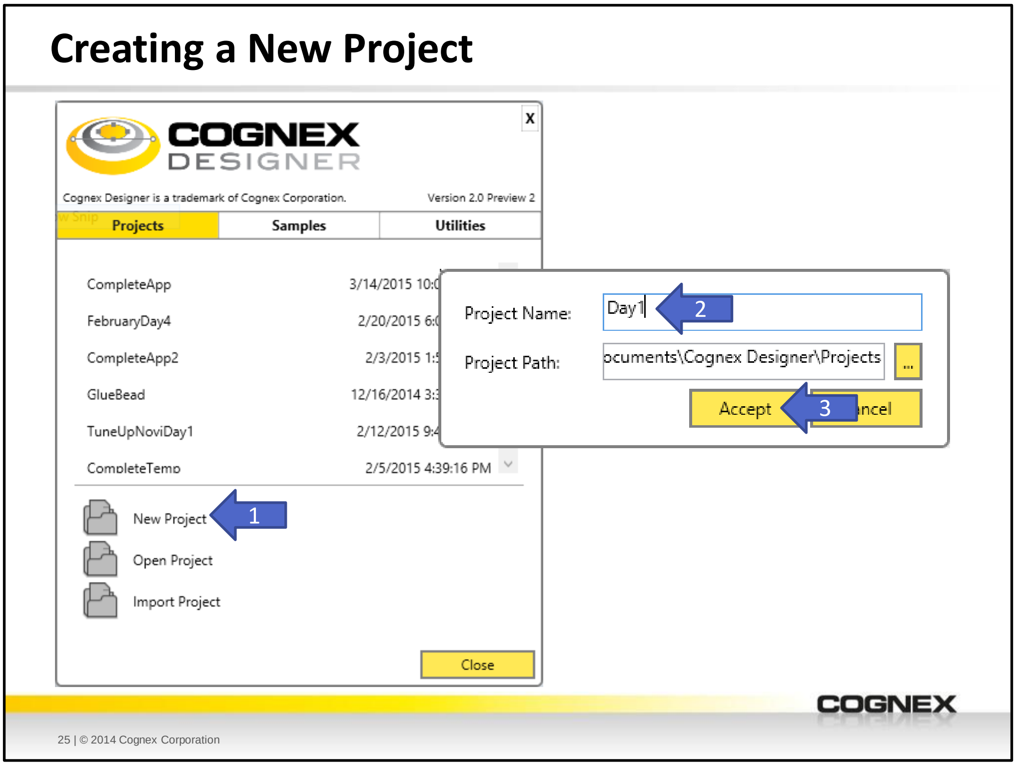


The utilities allows you to launch:

- Cognex GigE Vision Configurator
    - Helpful for configuring GigE Vision cameras connected to your network
- Cognex Comm Card Configurator
    - Configures Cognex configuration cards installed in your PC
- CogCLSerial
    - Configures CameraLink cameras connected to you PC
- Project Plugin Configurator
    - Configures Designer plugins installed on your PC

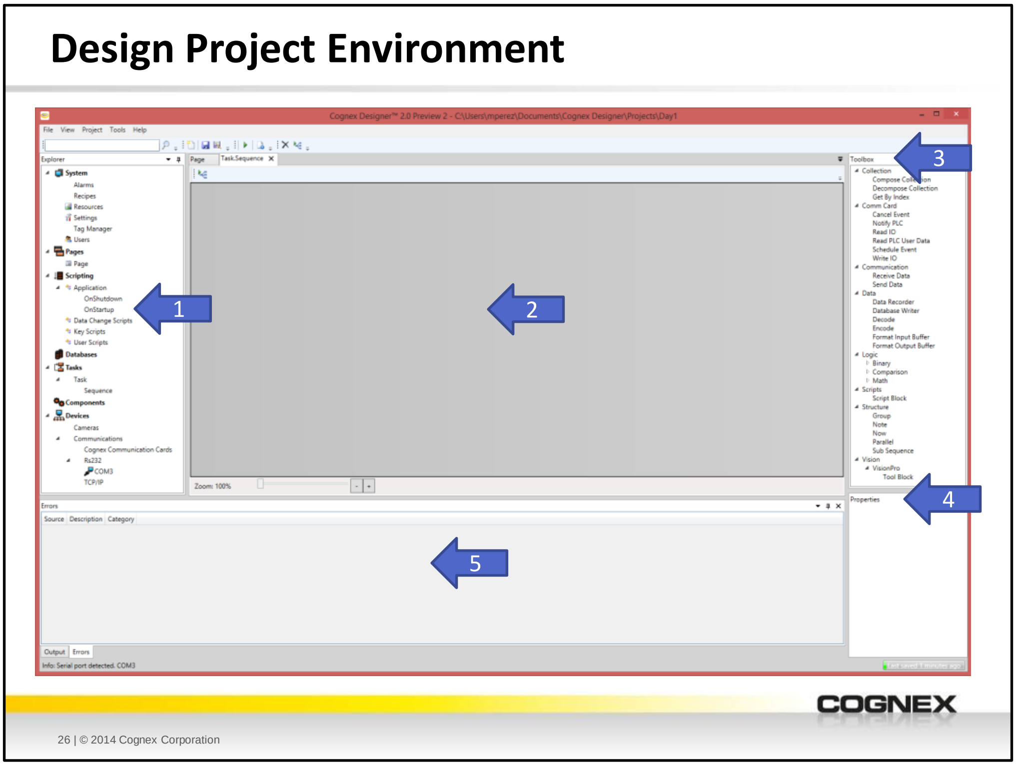


1. Open Cognex GigE Vision Configuration Tool
2. Find the listing for your Camera and the Network connection it’s under
3. Make sure eBus Universal Pro Driver is checked.
4. Follow this link under ‘properties and make sure to Set the following values
   a. Interrupt Moderation Rate = “Extreme”
   b. Jumbo Packet=9014 (or highest possible)
   c. Receive Buffer = 2048 (or highest possible)



To create a new project:

1. Click the New project icon
2. Give your project a name
3. Click Accept button

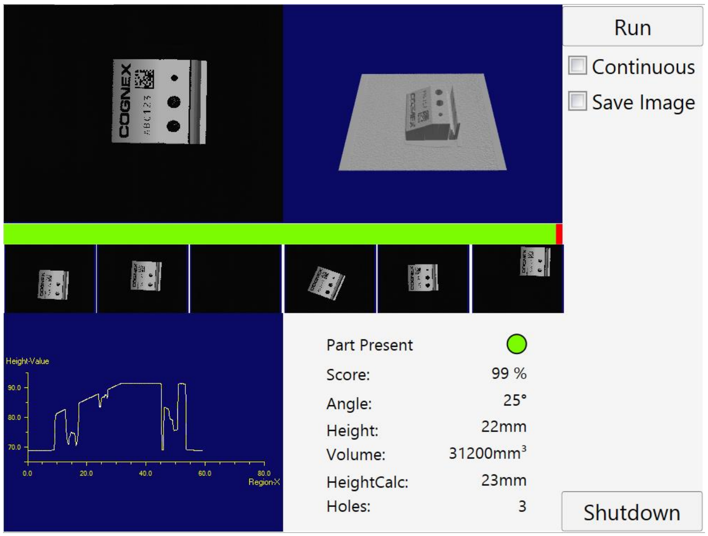


After Designer has launched we should see the following screen.

Designer is structured in 4 main areas:

1. The Explorer which organizes everything your project contains
    1. **Explorer – Area to create or link to resources (Cameras, DBs, User interface Pages, Etc.)**
2. The Designer Sequence area where you build up your application using sequence tools
    1. **Work Area – Area to place tools and make connections, tool assembly area.**
3. The ToolBox area where you can find the sequence tools and their properties
    1. **Toolbox – List of tools relevant to the current selection in Work Area.**
4. The Properties area where you can configure the sequence tool you are currently working with
    1. **Properties – Specific properties of tools selected in the work area**
5. Activated via the TOOLS pull-down menu,
   The Diagnostics area where you can access:
    - Errors listing
    - Watched items (such as values of your variables)
    - Project Verification feedback list
    - Output from project
    - Communication Monitor for checking data transfer

Sample Human Machine Interface (HMI)



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After the next few sections, we will end up with a basic application such as this. Subsequent sections will allow us to expand on our design and functionality.

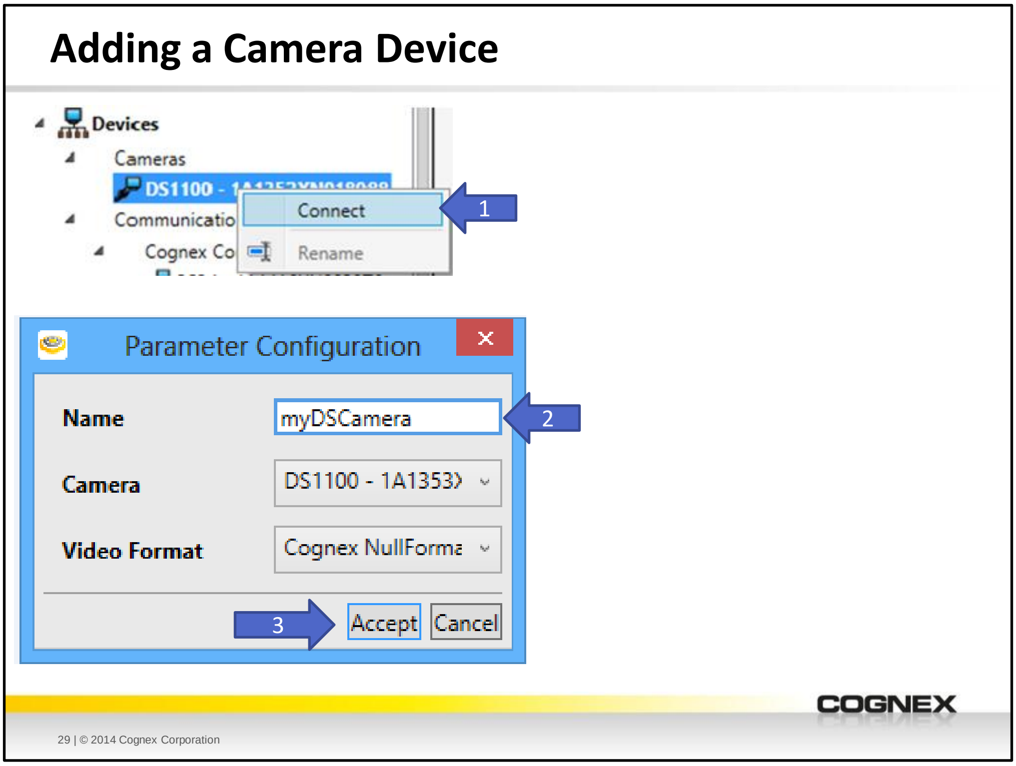
To start, we want to build a basic application that will trigger the camera, display the acquired image, and report found data points of our inspection.

Next Steps

1. Create a Camera Device
2. Create a Workflow
3. Tag Your Data
4. Create an user Interface

In the very first steps we will define building blocks such as Camera device and a Vision Sequence containing a PatMax Tool.

We will use these simple steps to additionally familiarize us with the concept of ToolBlock, pins, and VisionPro Vision Tool Controls.

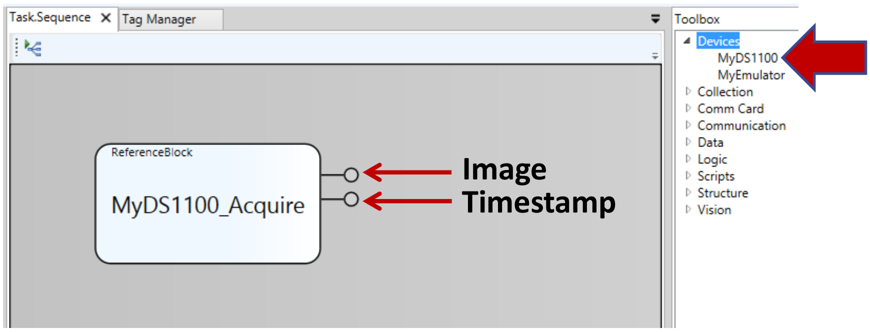


On the left hand side of the Designer you find an icon for Devices. If you right-click on the **Devices**, you can add a camera or an image file device. If the camera is not listed, you should go back to the GigE Vision Configuration tool to configure the camera. Once it is properly configured, it should appear on this list.

1) Find the camera you want connect to your project
2) Right-click on the camera icon
3) Select “Connect”
4) Give the camera a name that make sense to you e.g. MyDSSensor or DS1100
5) Verify the correct camera is selected (not really necessary now since you have only one camera)
6) Select from potential camera formats (currently only Cognex NullFormat is available)
7) Click “Accept”
8) Camera is now connected and ready for use within your project

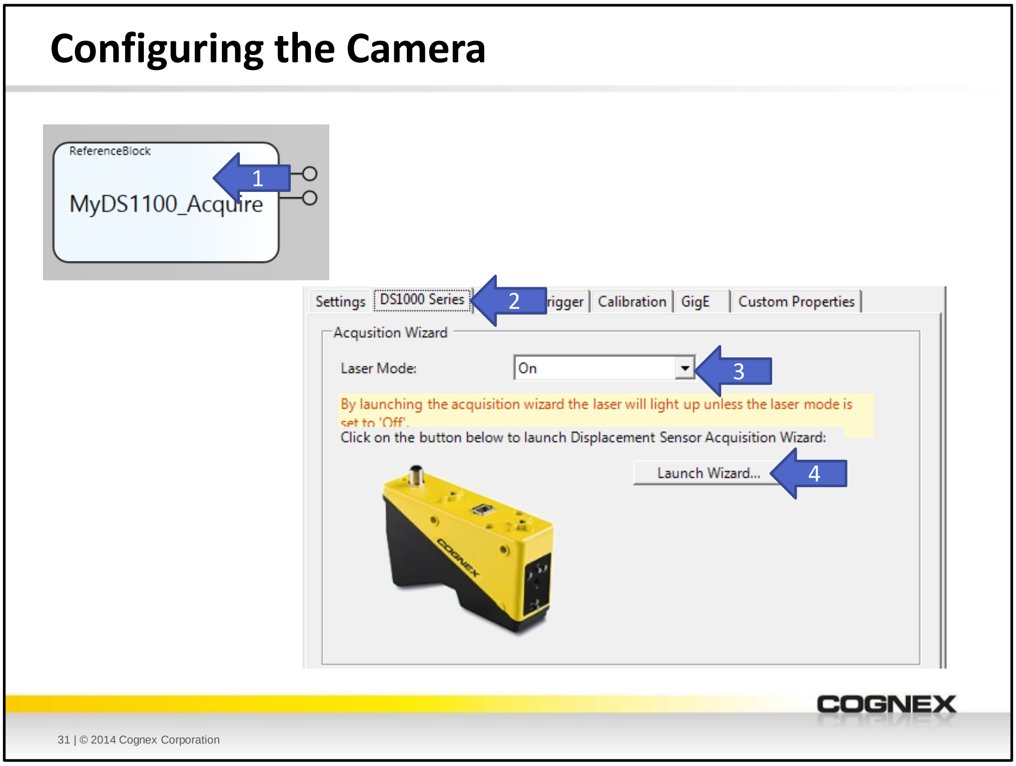
When complete, note the camera name in the list and the green checkmark indicating that this device is now connected with the system and available for use.

Adding a Tool Block to the Workflow



Expand the Devices category and drag and drop the device we recently added and named into the sequence area.
Notice that the device has two output terminals created by default. The actual terminals created will depend upon the camera being used. In this case, the camera being used has two output terminals.

- Top Terminal: Image – is the output of the image being taken by the camera (or next image in an image database)
- Bottom Terminal: Timestamp – is the unique timestamp of the image that changes every time an image is acquired



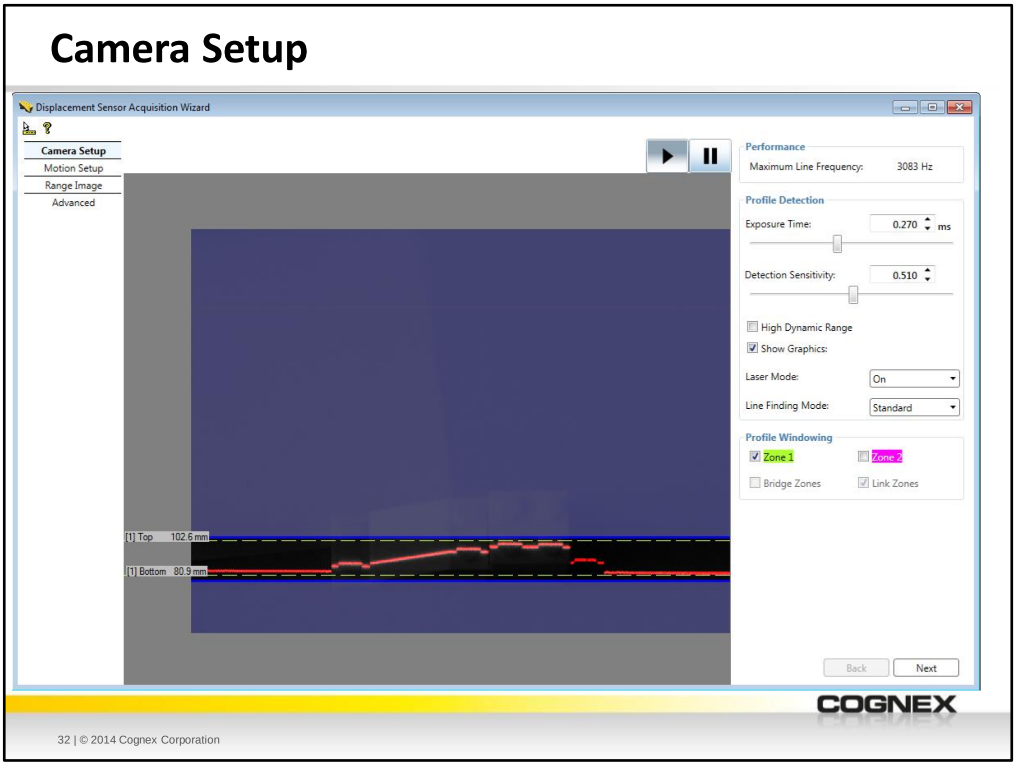
To configure the 3D sensor's camera and motion settings, you can use the Acquisition Wizard to guide you through the settings that you will need to adjust based on your project's needs.

The Acquisition Wizard allows us to setup up the 3D Sensor by using a step by step process that guides us to getting a great image right from the start.

The Acquisition Wizard gives us access to the most important settings necessary to get a great image for 3D inspections.

To open the Acquisition Wizard follow these steps:

1) Double-click on the newly added device block
2) Select the "DS1000 Series" tab
3) Set the "LASER Mode" to "On" and visually verify you have turn on your camera's LASER line
4) Click the "Launch Wizard…" button



Things to change on this page:

1- Exposure time (the amount of time the image sensor is accepting light data

2- Detection sensitivity (the strength of the light that is accepted as a “good reading”)

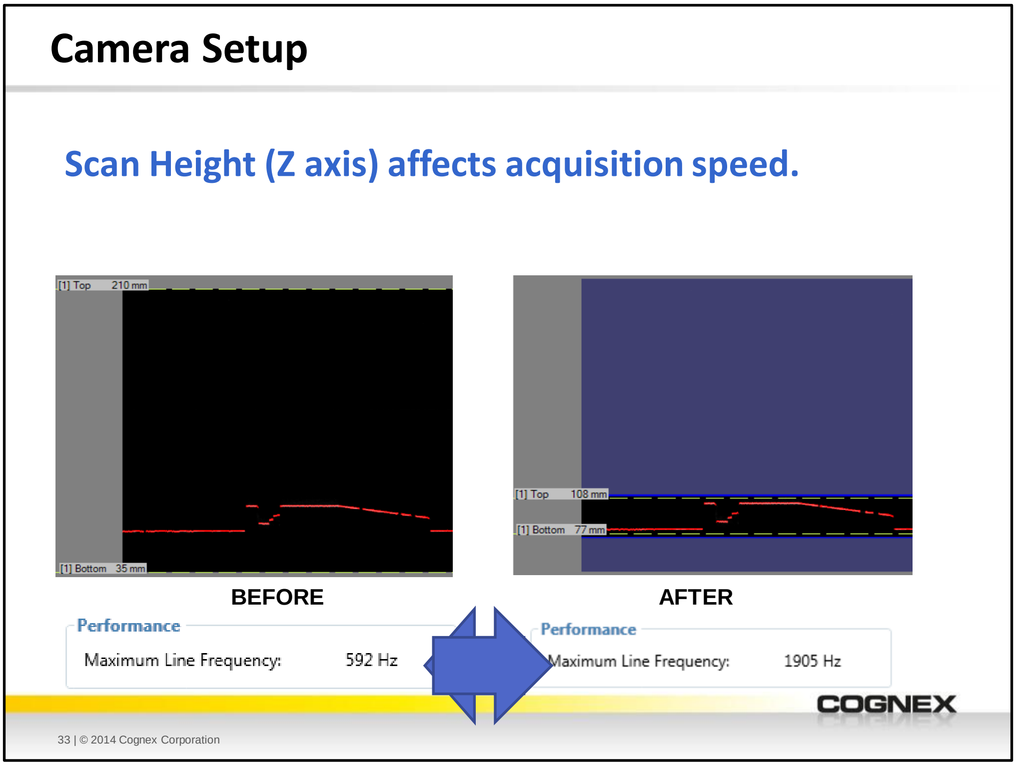
Other settings and data on this page:

1- maximum line frequency (how fast you can scan a part)
As you change other settings, this value can be affected.

2- Zone 1 and Zone 2 (heights the sensor analyzes, ignoring areas outside the zones)
having narrower zones increases Maximum Line Frequency

3- Laser Mode – turn to “on” for purposes of the class.
This sets when the laser will be turned on, always, during scan only (strobed) or OFF.

4- High Dynamic Range – might get you a better image under some circumstances.
otherwise cuts Max Line Frequency in half.



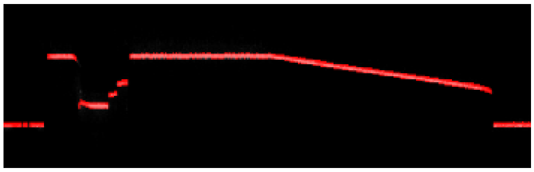
This is also the time to set the top and bottom of our inspection range. This will allows the camera to capture only the image details within this range.

This will allow the camera to capture images at a higher line frequency which means that parts may move faster under the camera.

Look for changes in the Maximum Line Frequency value as you adjust both the exposure and the top and bottom height ranges.

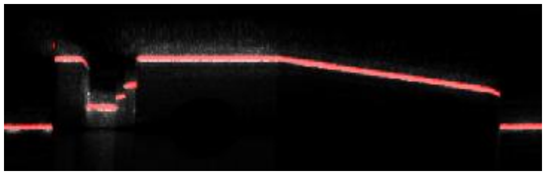
Setting the Right Exposure for Your Parts

Adequate Exposure



0.05ms

Overexposed



4.00ms

Sheet metal	0.1-0.5ms
Black Rubber	2-6ms
Different colors	0.1-5ms

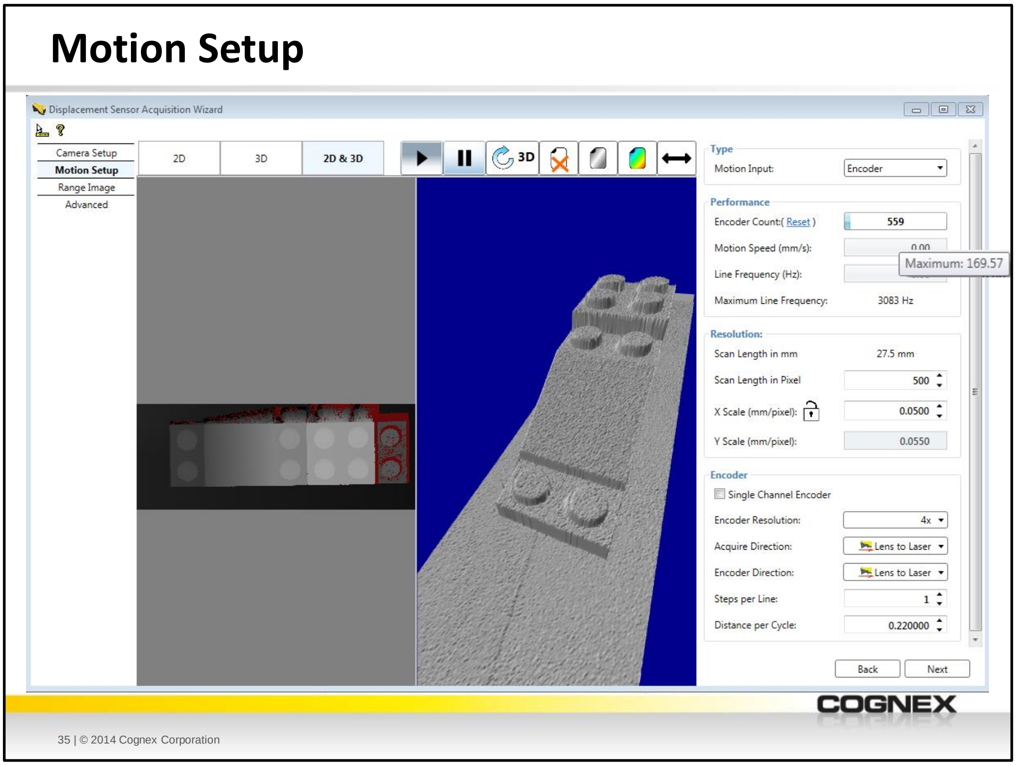
On the Settings tab, we can set the Exposure time of the camera in ms. Higher values let the camera collect more information about the LASER line reflected from the surface of the object under inspection and are therefore used for surfaces that are less reflective (for example, dark).

Exposure time setting recommendations:

- •Set Exposure time to avoid saturation, if possible.
- •Set Exposure time low enough to minimize or avoid spurious reflections, if possible.

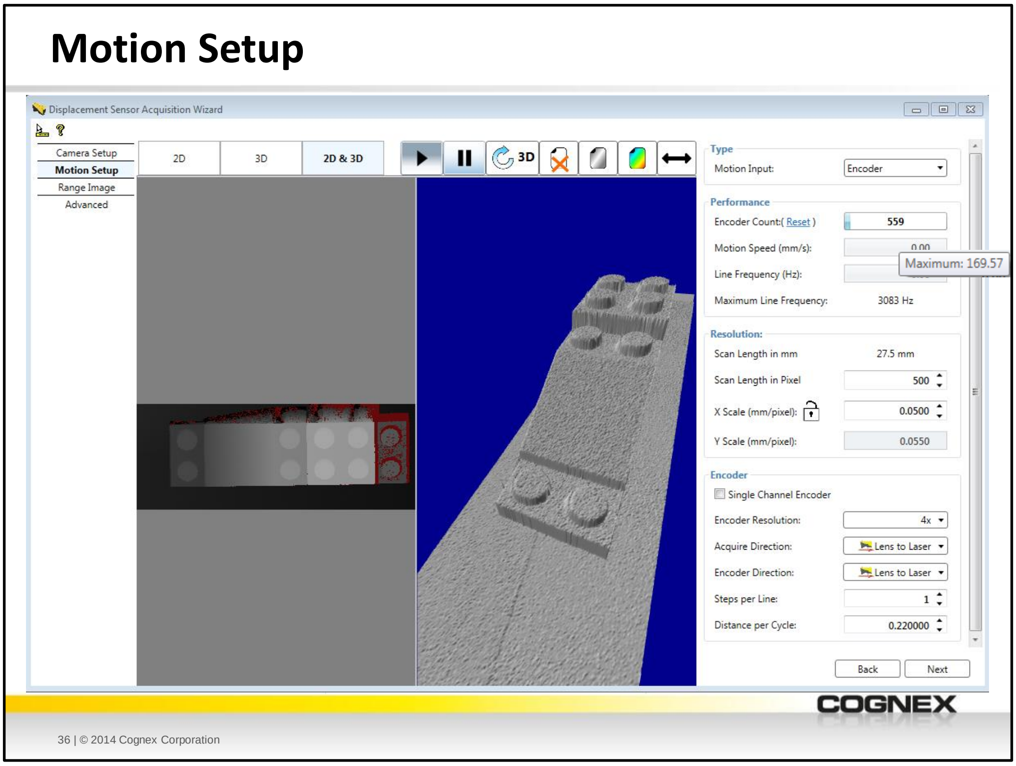
****Set exposure to have LASER line pixel intensity values in the range 40 through 245.****

A general rule of thumb we can apply for optimal LASER line detection is to set the exposure time in a manner that in the intensity image with graphics, the LASER line appears slightly narrower than the red line drawn by the software to indicate the locations of the LASER line segments the software has found.



Settings to change on this page:
1- Motion Input should be set to “encoder”
2- “steps per Line” should be set to 1. This is specific to the encoder used in the classroom.
3- “Distance per Cycle” should be set to 0.22 this is specific to the setup used in the classroom.

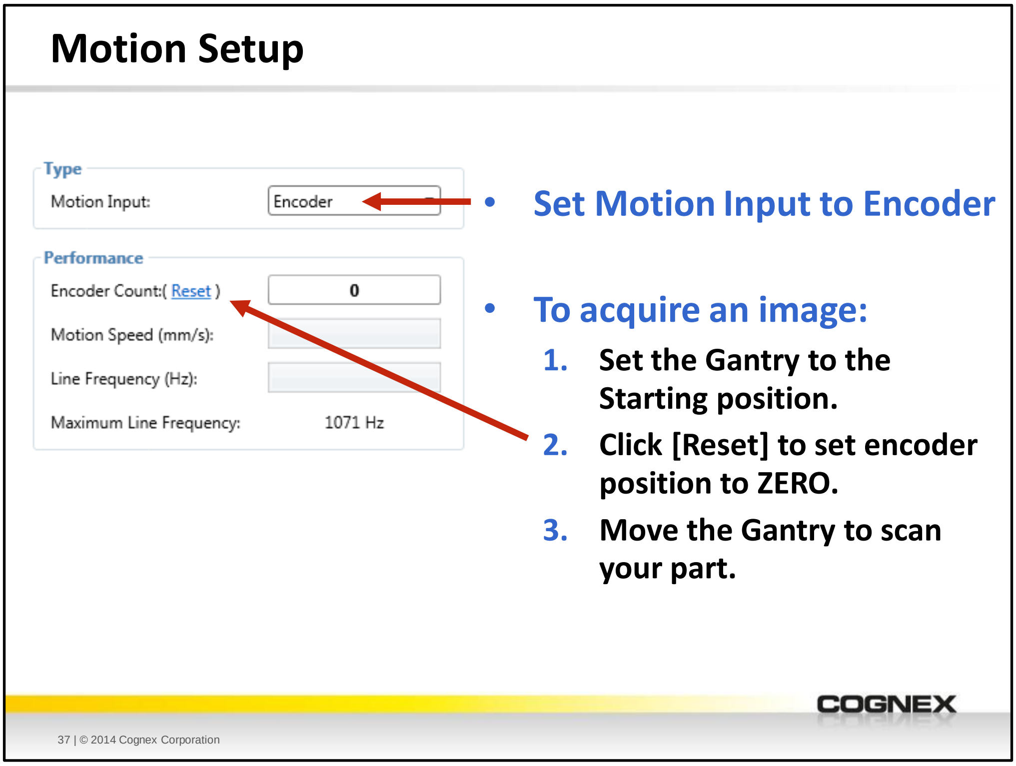
Other settings on this page:
-Encoder Count- can be reset to 0 to start acquiring a new image (covered on the next page)
-Motion Speed (mm/s)- this will have a value when you are scanning.
-Hover the mouse over this field to see your maximum mm/s that you can scan with the current settings.
-Scan Length in Pixels- This should be set to a value so that the Scan Length in MM is long enough for the part you want to scan.
-Make sure to leave some extra space before and after your part as you scan it. This will help in calculating the base plane.
-Acquire Direction and Encoder Direction can both be set to either “lens to laser” or “laser to lens”, and should be set according to your setup.
If your image is inverted, these two settings are the ones that need to be updated.



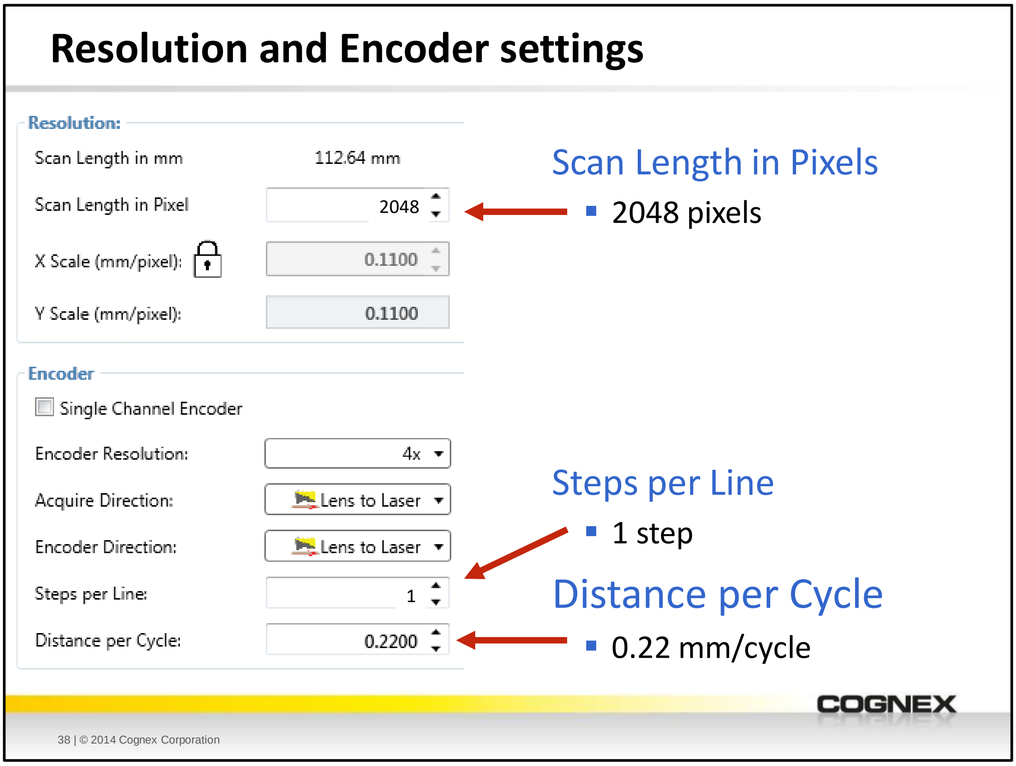
Calculating Settings:
Steps per cycle = Encoder Resolution *(for this encoder = 1024)
Cycles per step = inverse of Encoder Resolution (1/4)
Wheel Circumference = 223.1mm
Distance per cycle = Distance per step / Steps per cycle
Scan Length in mm = mm per cycle * cycles per step * steps per line * scan length (# of lines) in pixels

Deeper look with numbers:
distance per step = 223.1
steps per cycle = 1024 (encoder)
distance per step / steps per cycle = 0.217871094
Distance per cycle = 0.217871094

Encoder resolution = 4
cycles per step = inverse of encoder resolution = 0.25
steps per line = 1
scan length in pixels (set manually, as required)= 2048
Scan Length in mm = Distance per cycle * cycles per step * steps per line * scan length in pixels = 112.64mm



To start actually using the encoder, we must set the Motion Input to Encoder.
Encoderless is the default option which is constantly acquiring lines.
This can be used in place of an encoder if the line speed is kept constant.
This is not ideal for cases where the line starts and stops because the change in line speed will cause the image to appear stretched or smooshed when acquired.
For best results, use an encoder.



Notice that we automatically calculated the Scan Length in mm. This is the length in mm that your camera will use to acquire an image. Keep your eye on this value as you tweak these settings.

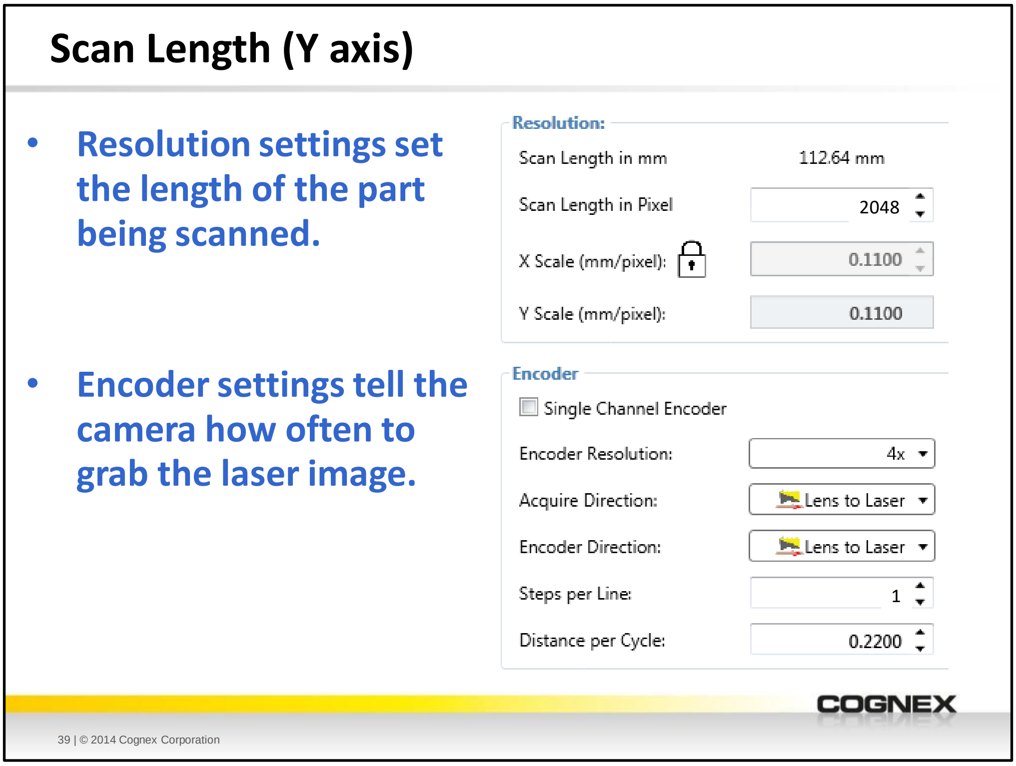
To set the proper settings we must know the length of the region we plan to scan. Take a moment to measure it now.

We'll use 2048 Scan Length in Pixels for this example, and if you are using a similarly sized part, then this setting should work. This means whatever distance we will be scanning (112.64mm) will be images over 2048 pixels.

If you part is longer, set it higher. Set it lower, is your part is shorter.

The rest of these settings are governed by your camera, encoder, and motion. We'll focus on those settings for you current setup:

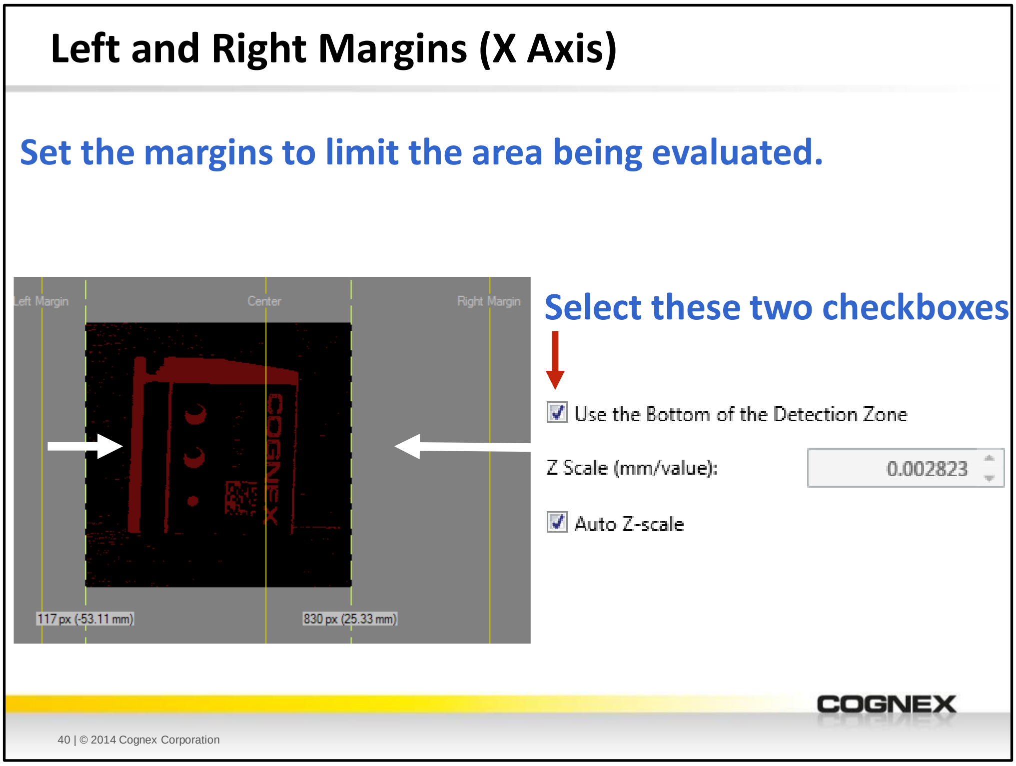
Encoder Resolution: 4x
Acquire Direction: The direction of motion when the camera should capture image lines
Encoder Direction: The direction of motion the encoder should capture ticks
Steps per Line: How many steps the encoder should interpret for each line
Distance per Cycle: Distance in mm per cycle of encoder signals (NOT wheel cycle) that the encoder should interpret



Once all our settings are configured, take a look at the Scan Length in mm calculation. This will be the length of the area that we will acquire in each image.

Make sure it makes sense by actually measuring the length of the region we will attempt to acquire and that length in mm is long enough.

If you need more, increase the Scan Length in pixels.
If you need less, lower Scan Length in pixels.



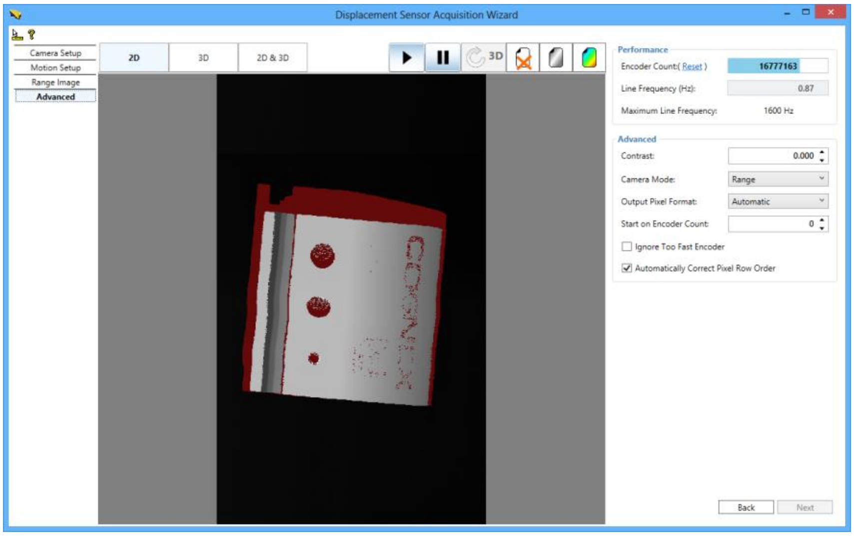
Reign in the left and right margins to better define the field of view you will use for our inspection.

In this same screen, we can enable the Use the Bottom of the Detection Zone and Auto Z-scale options.

These options will help us get the best contrast possible throughout the total height we defined when we set the top and bottom range.

> **Tip:** Move the right margin first, then the left. Note that the image moves over to the new left margin. Do not let that confuse you. Take a new image and note that the new margin is now being used.

Advanced



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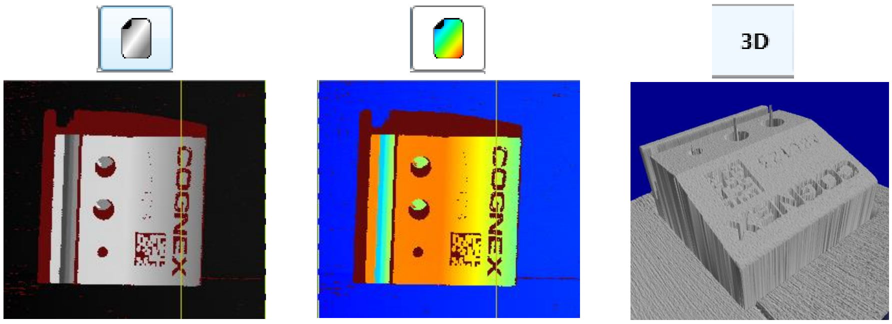
In Advanced settings you will find the following options useful:

- Start on Encoder Count: You can force a delay so that the image will wait until a particular number of encoder counts pass before the acquisition begins.
- Ignore Too Fast Encoder: If your part moves too quickly under the camera, the encoder will feed acquire signals too quickly which will cause an encoder overrun exception (error). You can ignore this error and only use the lines that can be acquired for the inspection.

Test Image Acquisition

1- Physically bring your encoder to the origin position
2- Reset the counter in software
3- Move the gantry to scan the part
4- View your rendered image



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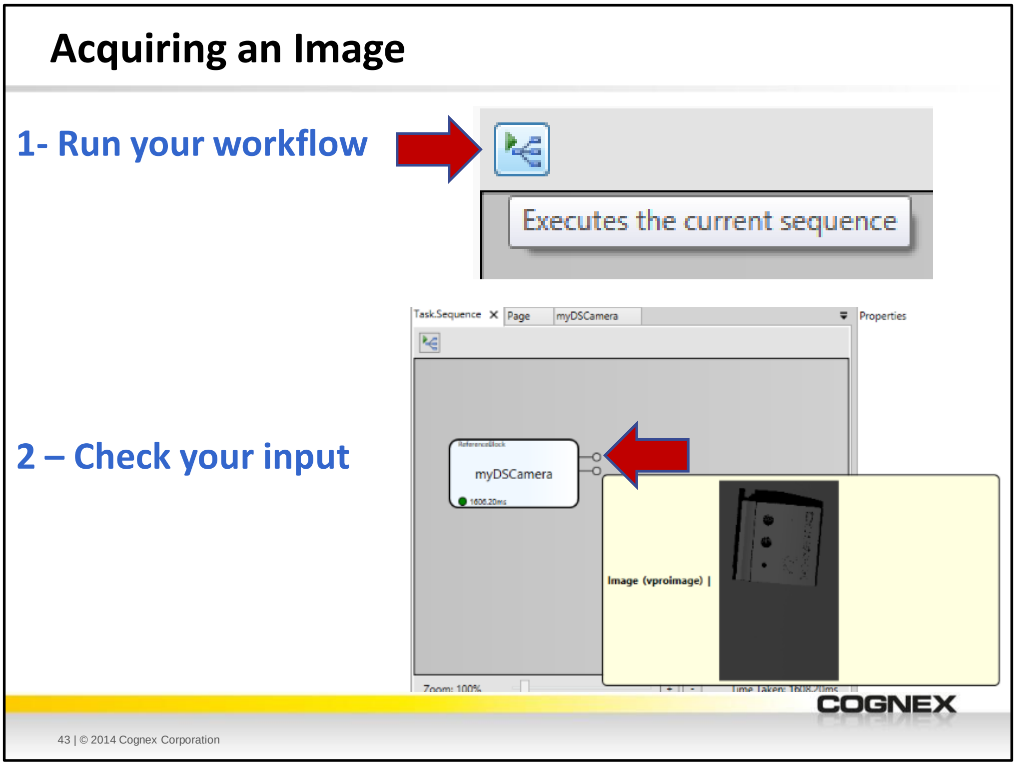
Let’s test our settings by bringing the part or gantry back to the origin position.

Click the Reset link and move the gantry system over the part or the part under the camera.

We should see the image forming line by line. Now use the controls over the display to review the 3D range image, the colorized version of the 3D range image mapping height with cool or warm colors, and the actual 3D model of your part.

Pan around and rotate the 3D model to see all the features being detected.



Close the Acquisition Wizard once you are happy with the image you are generating.

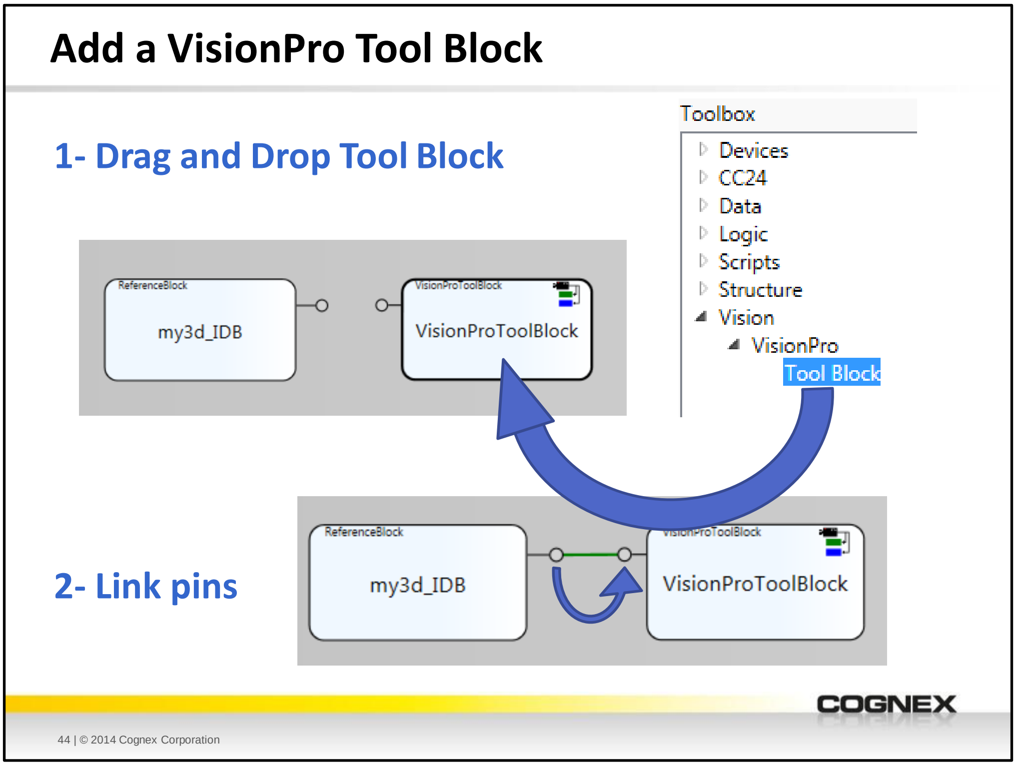
Back in the sequence view:

1) Click the Execute Sequence button at the top of the sequence window. This will cause the sequence to run once and the camera will wait for you to move the gantry over your part.

2) Promptly after clicking the Play button, move the gantry over the part until you see the timing update and a green indicator appear. The default timeout is 10 seconds so that’s how much time you’ll have to move the gantry and have the encoder tell the camera to acquire all the lines that will make up your image.

3) You can hover over the top tag to see the image that was acquired from a camera or the next image in an image database.

Pro tip: The acquisition time is noted in the bottom left-hand corner of the device block.



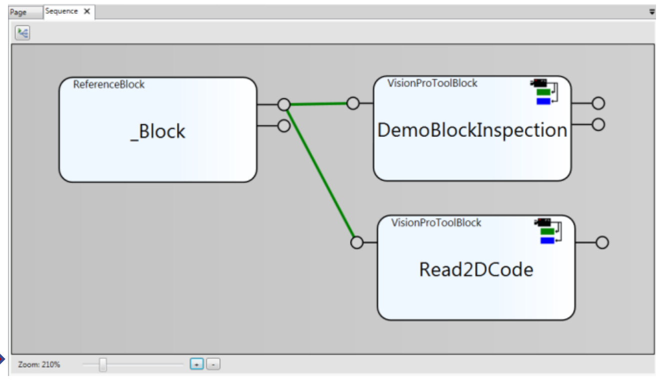
At this time, only VisionPro is available under the Vision object. It allows us to bring a ToolBlock into the application so that vision tools can be created and the part can undergo an inspection using the VisionPro suite of tools.

> **Note:** VisionPro 8.3 or later needs to be installed on the PC as well as Cognex Designer.

The Image tag of the Device needs to be feed into the input pin of the ToolBlock so the tools will have an image to work upon.

Navigating the Workflow

- **Select – Left-Click**
- **Pan – Right-Click the background + Drag**
- **Zoom – Mouse Wheel**
- **Edit – Double Click**
- **Options – Right Click**

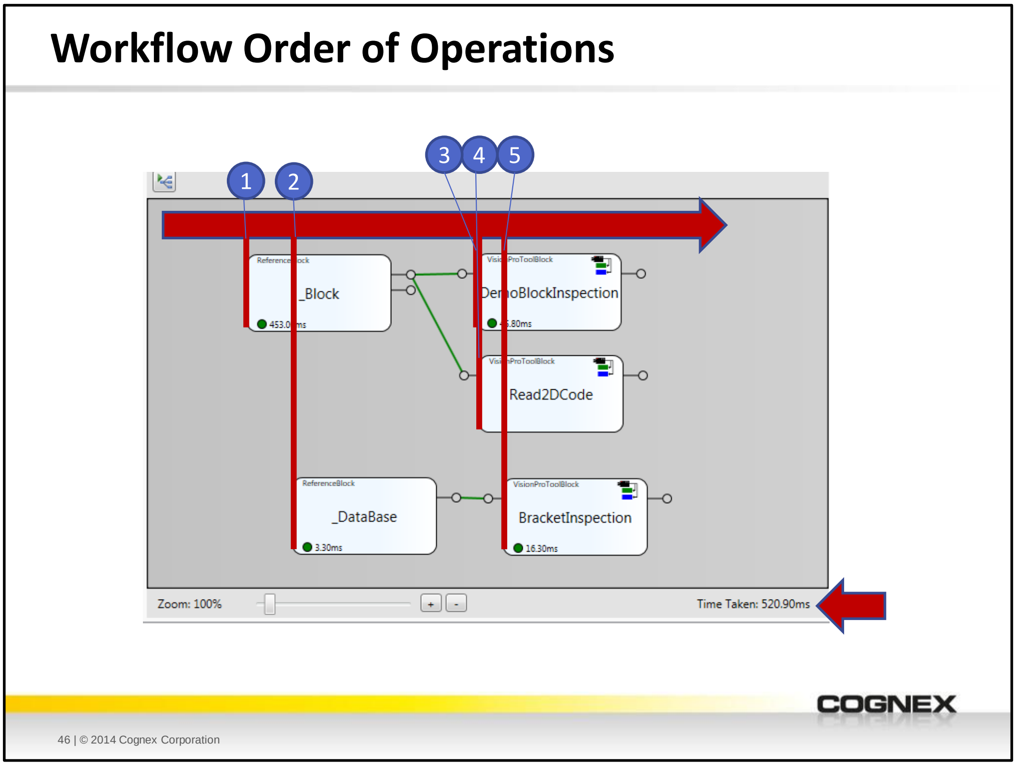


- **Alternate Zoom**

As the application starts to have more and more objects, it may be necessary to zoom into areas and the sequence and move around within it.

To zoom – select the "+" or "-" buttons next to the zoom in the lower left corner or adjust the slider bar
To Pan – hold down the right mouse button and move the mouse around within the viewable area.

If you have zoomed to much into an object where you cannot grab the background to pan, then hold down the Shift key while selecting the Left Mouse button. This is more useful on the HMI than on the sequence.



The Sequence acts as a basic flow diagram.

By default, it runs the objects serially – left to right based on the left most side of the object.

In this example, the order of execution is as follows:

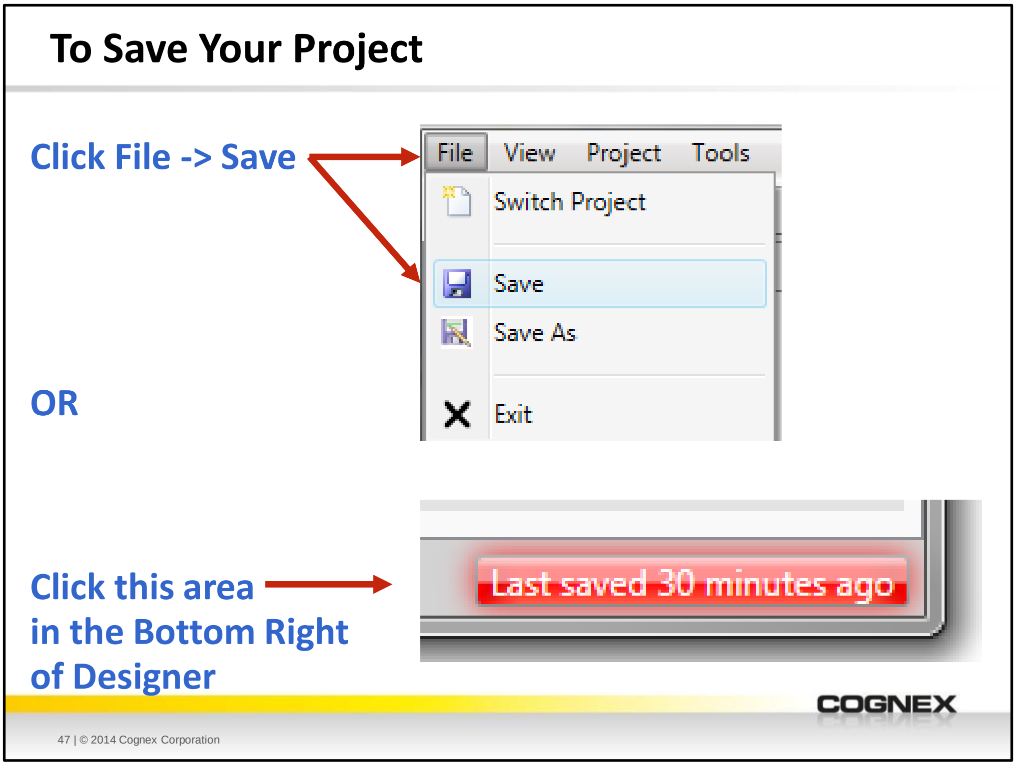
1) Block
2) Database
3) DemoBlockInspection
4) Read2DCode
5) BracketInspection

The total time is reported in the lower right corner

New Tasks can be created with other sequences to allow multi-threading and more complex application control.

Tasks with run in parallel with each other.

Sequences will run serially with respect to the task.



Saving an application is very similar to other software packages.

> "Save" will save the application back to where it was opened.
> "Save As…" will allow the user to choose where the application is saved.

The bottom right portion of the window will indicate when the application was last saved.

The graphic will be green if it is less than 10 minutes, then start changing to yellow between 11 and 24 minutes, and finally to red for anything longer than 25 minutes.

Pro Tip: Click on the save warning meter to quickly save yourwork.

Section 1 Summary

- Learned the basics of 3D imaging
- Launched Cognex Designer
- Configured a DS Camera using the Acquisition Wizard
- Scanned a good 3D image

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