Design Project 2

Xerox Printer

Velocity Measurement

EDSGN 100-Section 016

Team Number 6: The Peacocks

Submitted to: Wallace M. Catanach

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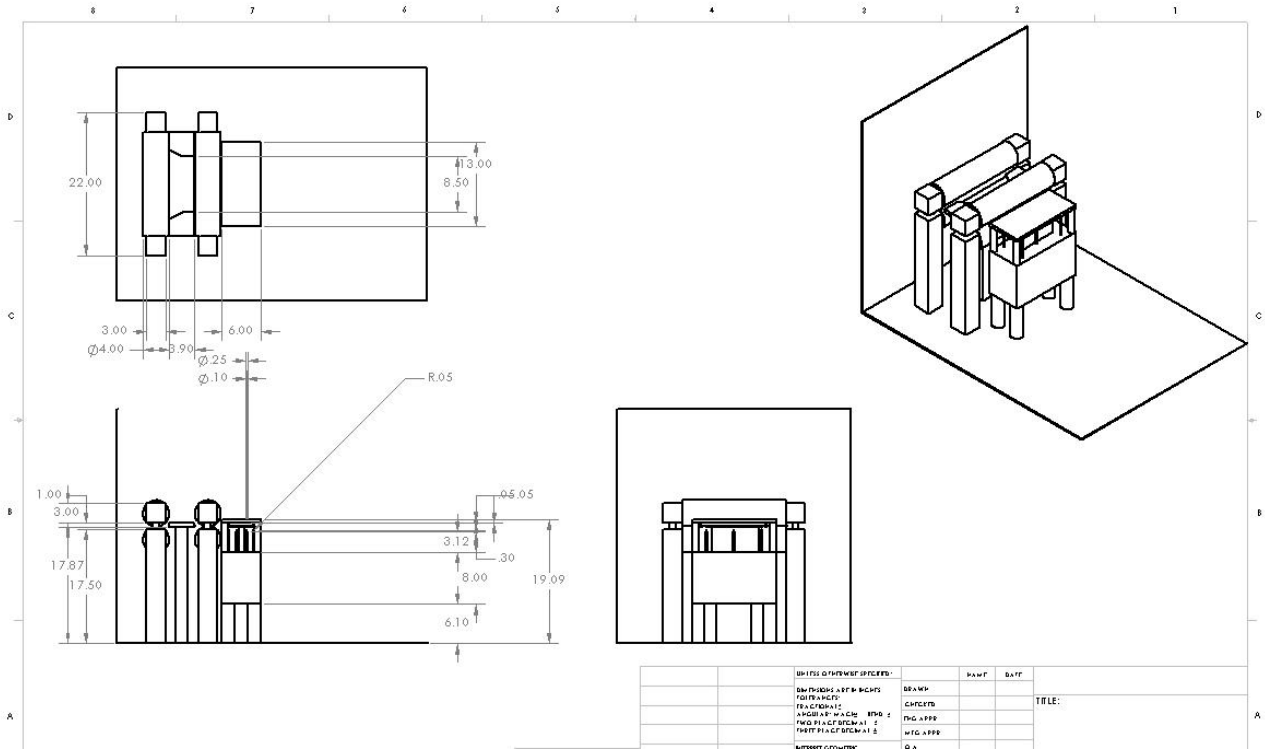
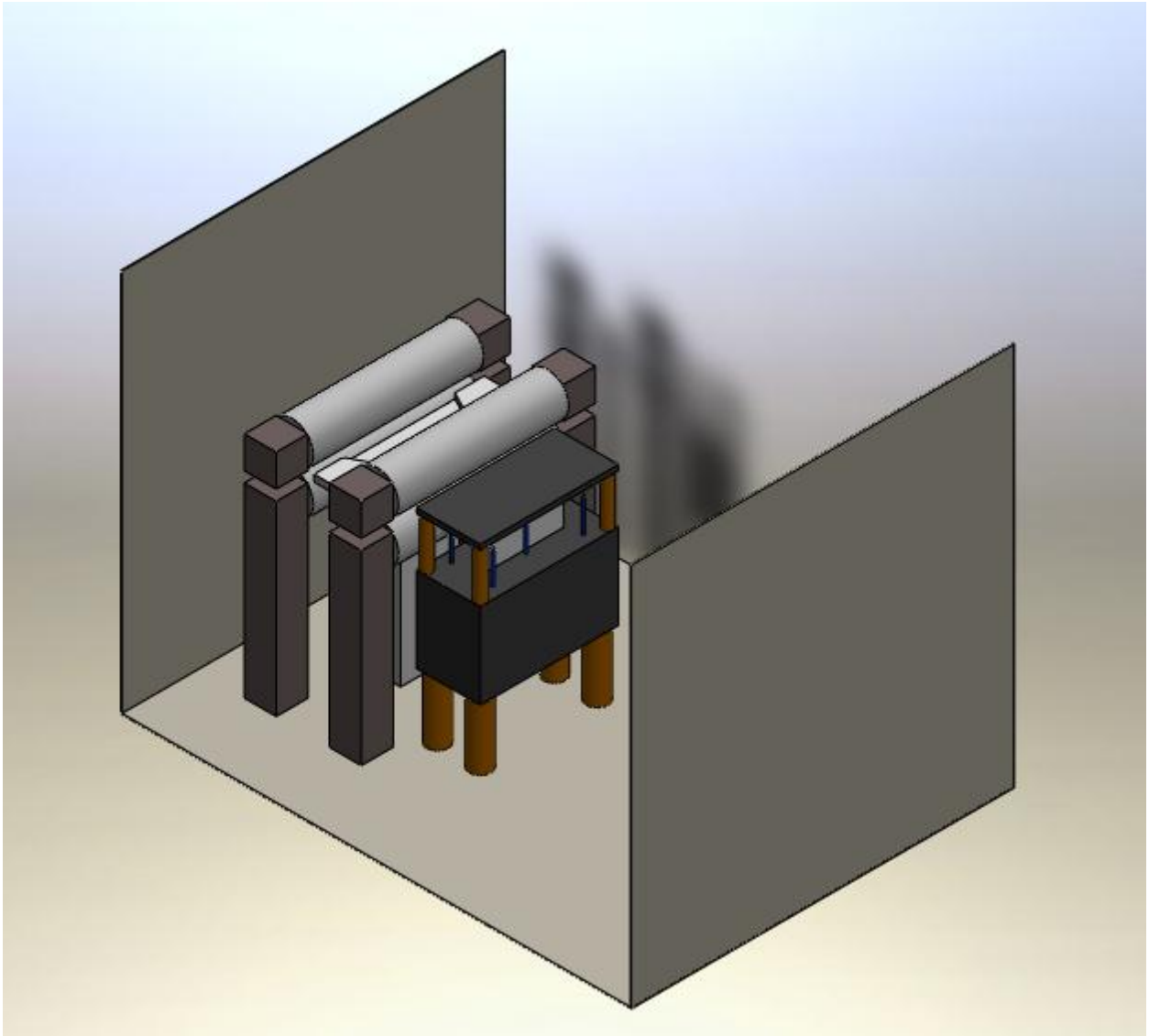
Descriptive Images of the Prototype and Model:

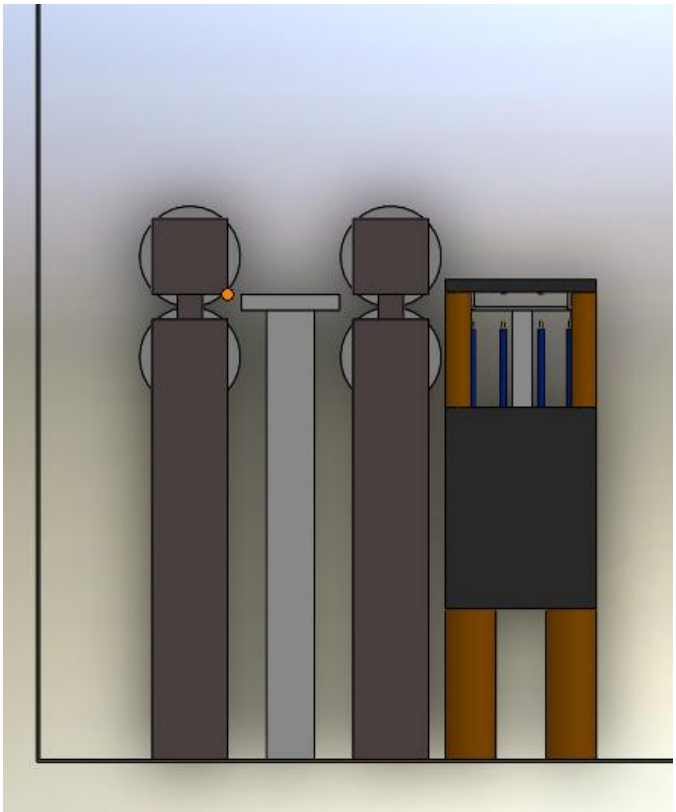
Drawing:



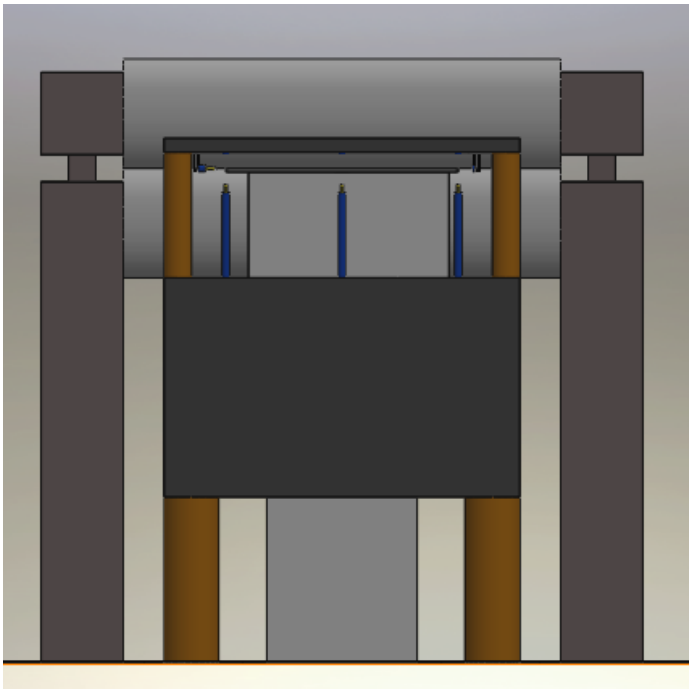
Isometric View:



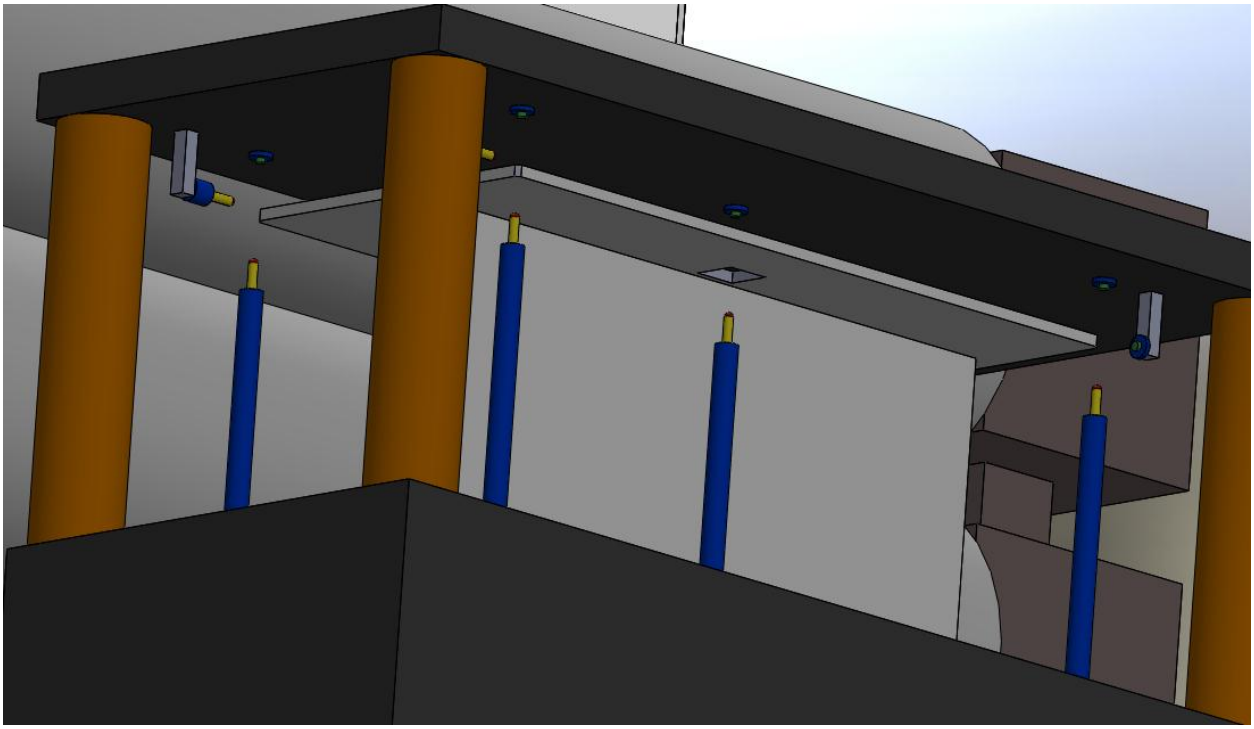
Front View:



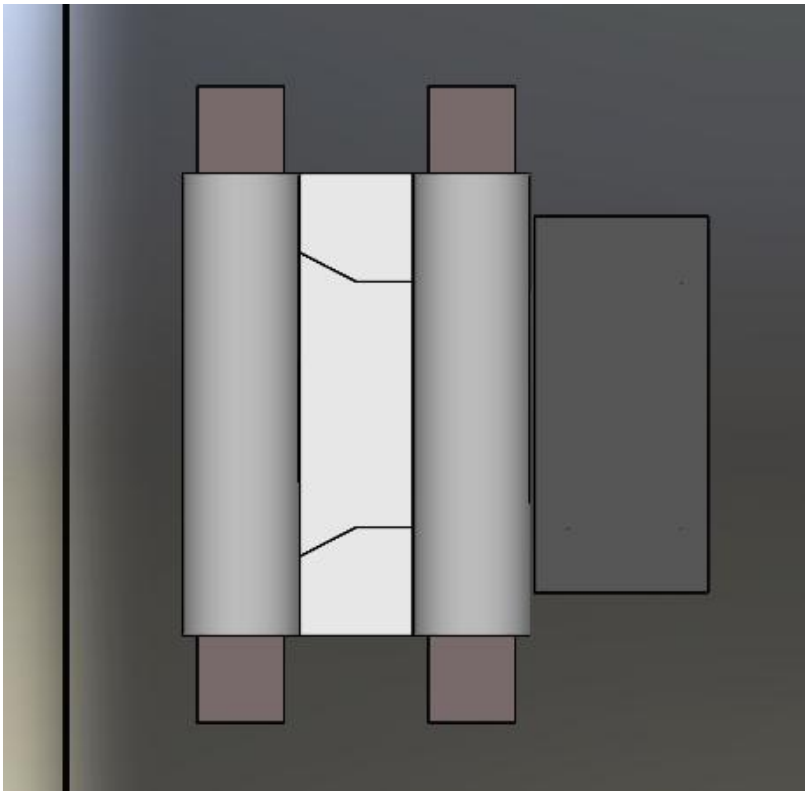
Right View:



Close Up View of Laser System:



Top view:



Abstract:

Team 6 has designed and built a model for a paper velocity device in a printer. This project focuses on the proper handling of paper given the variety in paper feedstock properties. The final specifications for the device were decided considering important factors such as, the speed variance, the thickness of the paper as well as the length and width of paper. We researched and analyzed the most suitable components that can detect the correct velocity of paper and have more precise timing control of the paper. The main components we used are lasers and rollers.

Introduction:

This project focuses on the part of Xerox that most of us are familiar with, printing. A paper velocity device conveys continuous sheets of paper along a definite conveyance direction and path. The actual speed that the paper moves may vary from that of the nominal speed. In these cases, an ideal device needs to be designed to account for different velocities of paper in order to achieve tight control tolerances while applying the ink to achieve maximum precision. Considering all these factors, we have designed a prototype with features that can determine the velocity of the sheet of paper, detect the edge of the paper, determine if the paper is flat, as well as making sure that the paper is straight and not bent. We explored different methods of measurements before choosing the best few at minimal cost.

Mission Statement:

Product Description	A paper velocity measurement device
Benefit proposition	Calculates paper velocity in printers so printing is more accurate
Key business goals	Device is able to accurately determine paper velocity in a printer while having a reasonable cost
Primary market	Xerox
Secondary market	Companies who use the iGen4
Assumptions	Integrates with iGen4, easy to use, little user work required, independent of printer parts
Stakeholders	Xerox, companies who use the iGen4

Customer Needs Analysis:

Need Number	Need	Importance
1	The device works independently from the driver roll speed.	5
2	The device works independently from the thickness of paper.	5
3	The device works independently from the diameter of drive roll.	5
4	The device works independently from the finish of paper.	5
5	The device works independently from the dimensions of paper.	5
6	The device is able to determine the velocity of a 8.5"x11" sheet of paper moving through a simple paper path.	5
7	The device is able to determine the velocity of a piece of paper moving between 250 and 750 mm/s.	5
8	The device is able to measure paper velocity within a tolerance of ±0.25%.	4
9	The device allows the sheet to maintain its current speed.	5
10	A prototype of a simple paper path using two drive rolls with a baffle works.	3
11	The device comes with documentation of a step-by-step measurement procedure.	3
12	The device minimizes cost.	2
13	The device requires little work on the user's part.	3

Needs-Metric Matrix

	Metric Number	1	2	3	4	5	6	7
	Units		mm/s	± %	mm/s			Dollars
	Metric	Device works for all kinds of paper and drive roll settings	Velocity measurement	Tolerance measurement	No effect on paper speed	Prototype works	Step-by-step procedure of measurement process	Affordable technology and production
Need #		x						
1	Independent from driver roll speed	x						
2	Independent from thickness of paper	x						
3	Independent from diameter of drive roll	x						
4	Independent from finish of paper	x						
5	Independent from paper dimensions	x						
6	Determines velocity of 8.5"x11" sheet of paper		x					
7	Determines velocity between 250-750 mm/s		x					
8	Paper velocity within tolerance of ±0.25%			x				
9	Device allows paper to maintain current speed	x			x			
10	Prototype of simple paper path with two drive-rolls with baffle	x				x		
11	Documentation of measurement procedure						x	
12	Minimizes cost							x
13	Little work on user's part	x					x	

External Research:

iGen 4 Information:

- Estimated use is 200,000 to 3,750,000 per month
- Many types of paper are able to be used
- Uses automation for some operator tasks to be faster
- Able to print over 4 million pages per month
- Using non-toxic dry inks to minimize waste
- Uses spectrophotmeter automatic color adjustments and calibrations to keep very high accuracy
- Able to hold up to 80,000 sheets of paper

"Xerox IGen4 Digital Press: Advanced Color for Many Applications." *Xerox Document Management, Digital Printing Equipment, Business Process Outsourcing*. Web. 10 Nov. 2011. <http://www.xerox.com/digital-printing/digital-printing-press/color-printing/xerox-igen4/enus.html>.

Paper path Information:

- Rollers come in contact with surface of print as it is being ejected
- Some printers use U-shaped path to feed paper from tray to the ink location to the front
- The best paper pather is straight. These feed from back straight to the front. This is best because it allows for printing many types of media on different surfaces

"Working with Ink-jet Printers." *Golden Artist Colors, Inc.* Web. 10 Nov. 2011. <http://www.goldenpaints.com/mixmoremedia/workprint.php>.

How small printers like HP measure printing speed:

- measures in pages per minute (PPM)
    - when the first page hits the tray to when the last page hits tray
    - when “OK” button is pressed until first page hits tray

"How HP Measures Inkjet Printing Speed." *HP - United States | Laptop Computers, Desktops, Printers, Servers and More*. Web. 10 Nov. 2011. <http://www.hp.com/products1/inkjetprinter/printing_speed.html>.

Photogates:

- timing device for things that are faster than can be timed by hand
- consists of infrared diode & photocell
    - timing begins when laser beam between diode & photocell is interrupted
- allows for extremely accurate timing

"The Quick and Dirty on Photogates." *Waukesha South High School*. Web. 8 Nov. 2011. <http://www.waukeshasouth.com/physics1/photo.html>.

Photoelectric Sensor Information:

- detects beam of light & responds to change in intensity of beam
- beam may be invisible or invisible
- emitter: contains LED light source it sends to receiver
- receiver: decodes beam of light

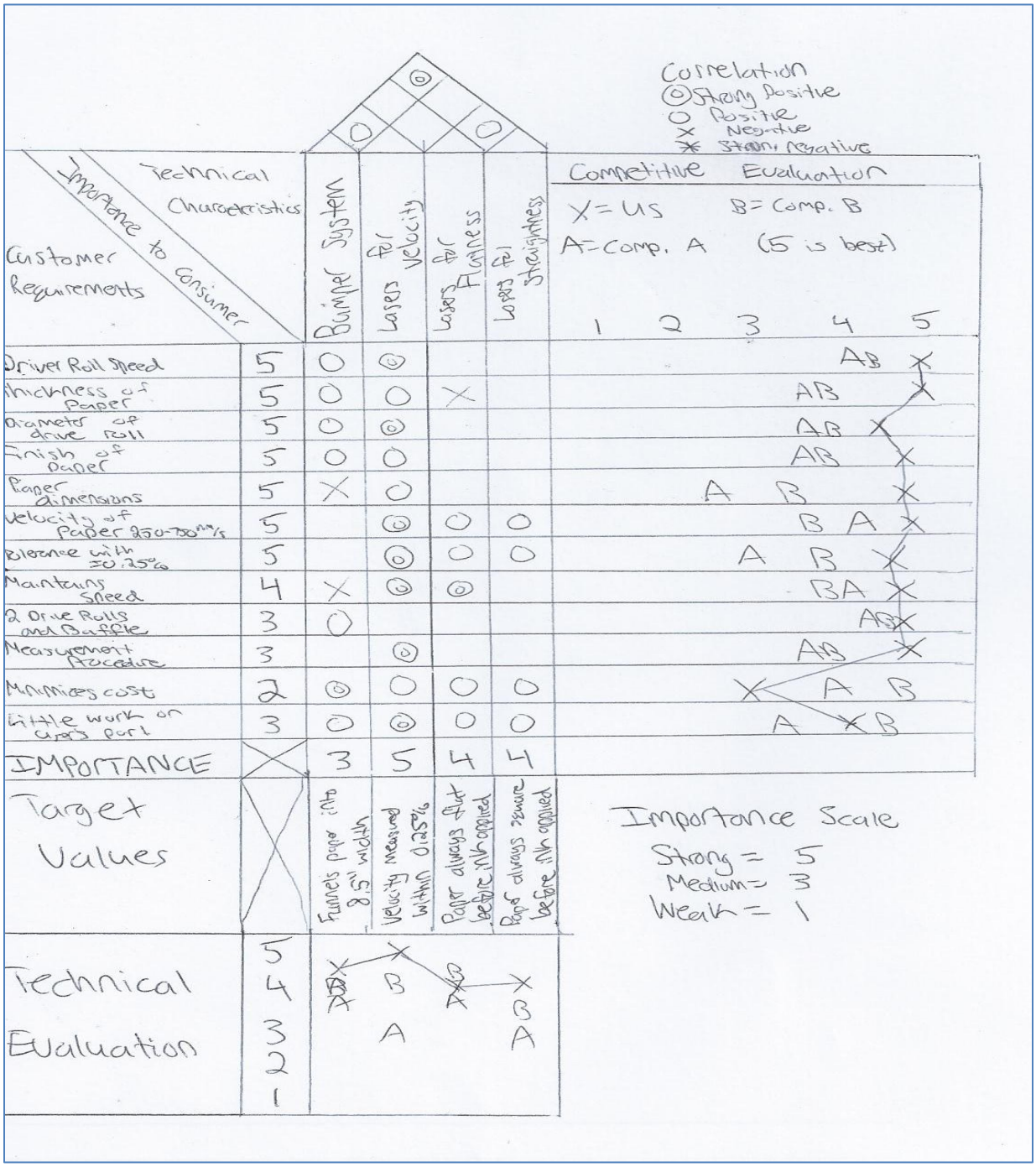
"Banner IKnow Guide to Sensing: First Edition." *Bannerengineering.com*. Banner Engineering Corporation. Web. 10 Nov. 2011. <http://info.bannerengineering.com/xpedio/groups/public/documents/literature/120236.pdf>.

Photoelectric Sensor Information:

- detect presence, absence, or distance of target objects
- through beam/opposed
    - emitter & receiver opposite of each other & detect when beam is broke
- retroflective
    - emitter & receiver on same side
    - reflector bounces beam back
- proximity
    - same as retroflective, beam bounces back on object, not reflector
    - can measure distance from object
    - 5 subcategories
- wide variety strengths, sizes, shapes

"Photoelectric Sensors Information." *GlobalSpec*. Web. 10 Nov. 2011. <http://www.globalspec.com/learnmore/sensors_transducers_detectors/proximity_presence_sensing/photoelectric_sensors>.

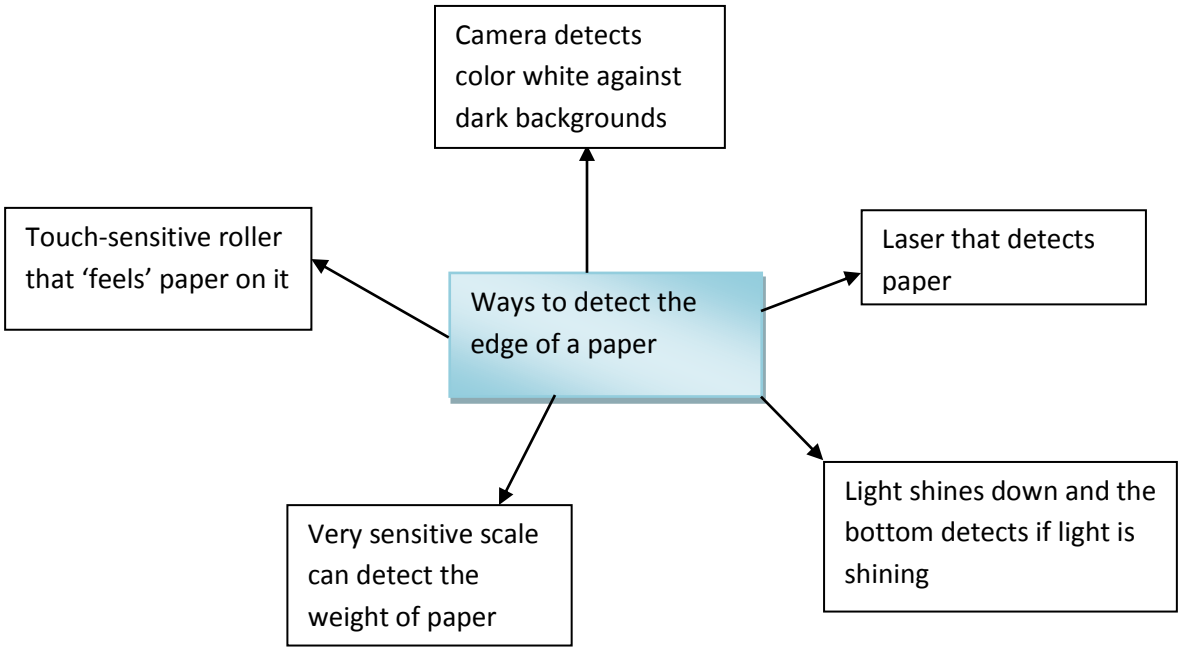
House of Quality

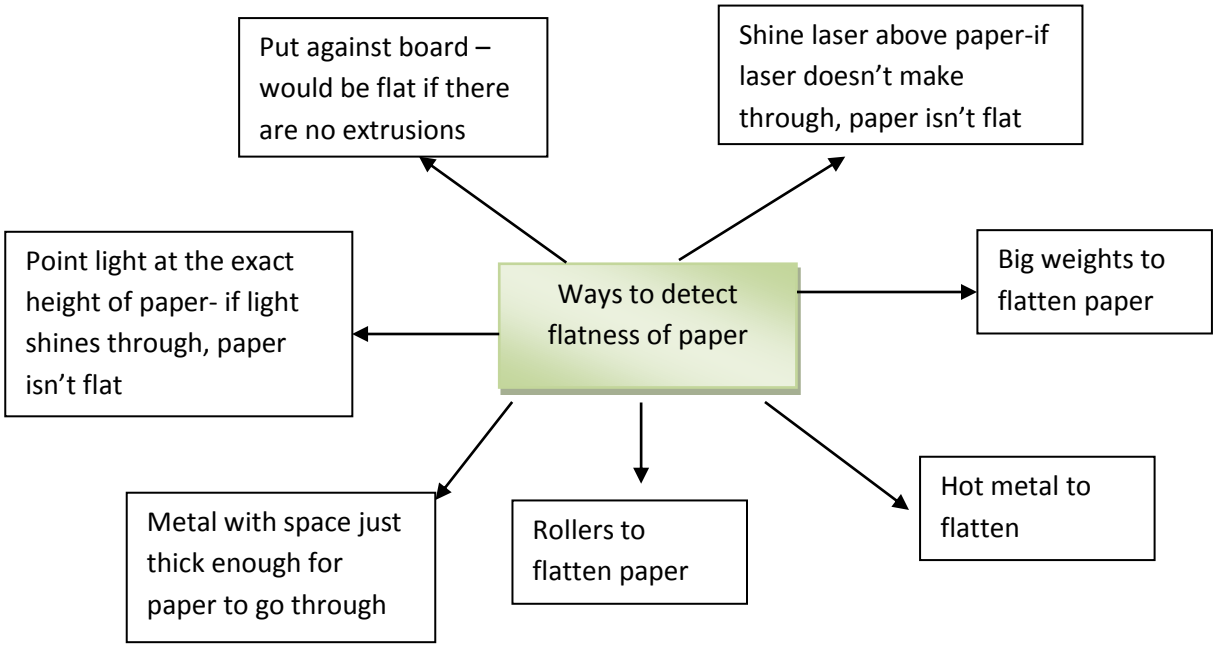


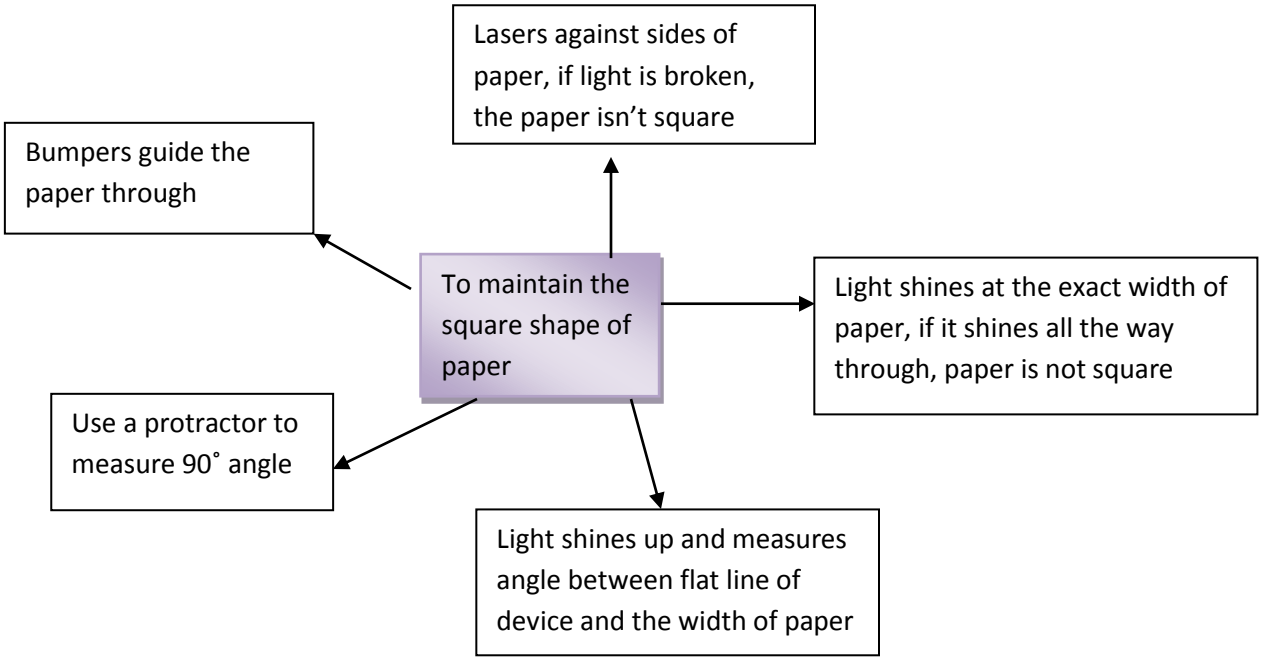
Global Marketplace

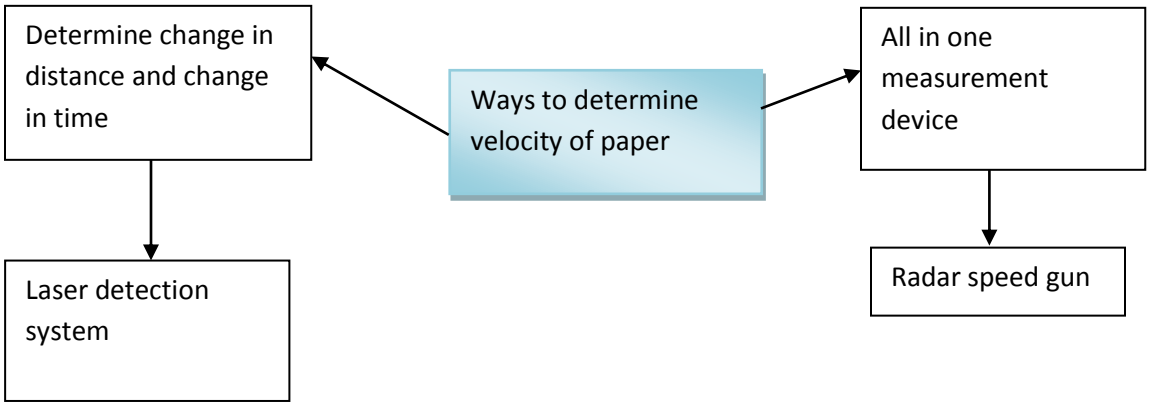
	Xerox iGen4	**HP Officejet Pro 8600 Premium**	**Canon| imageCLASS MF4570dn**
Rated speed	Range depending on paper size: from 120 ipm for 7" x 7" to 40 ipm for 14.33 x 22.5"	-Draft print speed - Black Up to 35 ppm## -ISO (Laser Comparable) print speed - Black Up to 20 ppm## -Draft print speed - Color Up to 35 ppm## -ISO (Laser Comparable) print speed - Color Up to 16 ppm##	Black: Up to 26 ppm (letter)
Print resolution	4800 × 600 × 1-bit	-Black print resolution Up to 1200 x 600 dpi -Color print resolution Up to 4800 x 1200 optimized dpi on HP Advanced Photo paper, 1200 x 1200 input dpi	Black: Up to 600 x 600 dpi 1200 x 600 dpi quality
Standard paper capacity	30,000 sheets	250-sheet input tray	250-sheet cassette
Maximum Paper weight	130 lb.	27.83 lb.	43 lb.
Standard interfaces	Ethernet 10/100 baseT Protocols: TCP/IP, AppleTalk, Novell IPX/SPX, Net BEUI, EtherTalk® Phase II, LPR/LPD	Standard (built-in Ethernet, WiFi 802.11b/g/n) USB 2.0; 1 Ethernet; 1 WiFi 802.11b/g/n; 2 RJ-11 modem ports	USB 2.0 Hi-Speed, 10/100 Base-T Ethernet (Network)

Concept Generation:









Concept Selection:

After considering all of the possibilities and options, we narrowed our final specifications down based upon the customer needs. We used concept screening and selection and combined or kept the best ideas and discarded the rest.

Concept Screening: Velocity Measurement

	Selection Criteria	A	B
Metric #		Lasers act as	Radar Speed
		timer/distance	Gun
1	Works for all kinds of paper/drive roll settings	+	+
2	Velocity Measurement within 250-750 mm/s	+	-
3	Velocity Tolerance Within ±0.25%	+	-
4	No effect on paper speed	+	+
5	Prototype works	0	0
6	Step-by-step procedure of measurement process	0	0
7	Affordable technology/production	+	+
	Sum +'s	5	3
	Sum –'s	0	2
	Net Score	5	1
	Rank	1	2
	Continue?	Yes	No

Concept Screening: Paper Edge Detection

	Selection Criteria	A	B	C	D
Metric #		Touch sensitive	Laser system	Camera detects	Sensitive
		roller		black vs. white	weight scale
1	Works for all kinds of paper/drive roll settings	+	+	-	+
2	Velocity Measurement within 250-750 mm/s	0	0	0	0
3	Velocity Tolerance Within ±0.25%	0	0	0	0
4	No effect on paper speed	-	+	+	-
5	Prototype works	0	0	0	0
6	Step-by-step procedure of measurement process	0	0	0	0
7	Affordable technology/production	0	+	0	-
	Sum +'s	1	3	1	1
	Sum –'s	1	0	1	2
	Net Score	0	3	0	-1
	Rank	2	1	2	4
	Continue?	Yes	Yes	Yes	No

Concept Screening: Flatness

	Selection Criteria	A	B	C	D
Metric #		Laser system	Very small	Rollers to	Big weights
		above/below	space to enter	flatten	to flatten
1	Works for all kinds of paper/drive roll settings	+	-	0	0
2	Velocity Measurement within 250-750 mm/s	0	0	0	0
3	Velocity Tolerance Within ±0.25%	0	0	0	0
4	No effect on paper speed	+	+	-	-
5	Prototype works	0	0	0	0
6	Step-by-step procedure of measurement process	0	0	0	0
7	Affordable technology/production	+	+	+	+
	Sum +'s	3	2	1	1
	Sum -'s	0	1	1	1
	Net Score	3	1	0	0
	Rank	1	2	3	3
	Continue?	Yes	Yes	No	No

Concept Screening: Straight/Square

	Selection Criteria	A	B	C
Metric #		Lasers along	Adjustable	Touch sensors
		side of paper	"bumpers"	along side
1	Works for all kinds of paper/drive roll settings	+	+	0
2	Velocity Measurement within 250-750 mm/s	0	0	0
3	Velocity Tolerance Within ±0.25%	0	0	0
4	No effect on paper speed	+	+	+
5	Prototype works	0	0	0
6	Step-by-step procedure of measurement process	0	0	0
7	Affordable technology/production	+	+	-
	Sum +'s	3	3	1
	Sum -'s	0	0	1
	Net Score	3	3	0
	Rank	1	1	3
	Continue?	Yes	Yes	No

Concept Scoring Matrix

	Detect Edge	Detect Edge	Detect Edge	Flatness	Flatness	Flatness	Square	Square	Square	Velocity	Velocity	Velocity
Selection Criteria	Touch sensitive roller	Laser that detects edge	Camera detects black vs. white	Laser above detects bending	Rollers flatten right before	"Sandwich" with only enough space for paper	Bumpers to guide paper through	Light path directly above	Lasers along each side of paper	Radar Speed Gun	Set of lasers a set distance apart	Touch sensitive plates a set distance apart
Independent of driver roll speed (8)	3	5	5	5	3	5	4	4	4	4	4	4
Independent of thickness of paper (8)	5	5	5	5	2	1	4	2	3	4	4	4
Independent of diameter of drive roll (8)	5	5	5	5	3	5	4	4	4	4	4	4
Independent of finish of paper (8)	4	5	3	5	3	4	4	4	4	4	4	4
Independent of dimensions of paper (8)	5	5	5	5	4	2	3	1	2	4	4	4
Detects paper speed between 250-750 mm/s +/-2.5% (10)	0	0	0	0	0	0	0	0	0	5	5	5
Works with two drive rolls with baffle between rolls (8)	4	5	5	5	4	5	3	3	3	5	5	5
Device has no impact on speed of paper (8)	2	5	5	5	2	4	4	4	4	5	5	5
Affordable (3)	2	4	3	4	4	4	5	5	4	3	4	2
Easy to modify specifications according to job (5)	3	4	2	4	3	2	3	1	4	5	5	2
Sum	245	312	312	312	195	230	238	196	224	314	317	296

Embodiment Design and Final Design Description:

Our final design incorporates many methods in order to achieve all of the customer requirements. The first component of the device is the bumper system between the rollers. The bumper system funnels the paper as it comes between the rollers. The funnel is angular to help guide the sheet of paper into the final width of 8.5”. The funnel can be adjusted to different widths of paper by changing settings on the main interface. The funnel then compresses or expands to make the final width of the funnel barely larger than the width of the paper.

The next component of the system also deals with making sure that the paper is straight before it transfers to the inking component of the printer. After the paper leaves the funnel, there is still a possibility that something could happen and the paper could become angled. There are four lasers and sensors that are used to determine whether or not the paper is perfectly straight. The lasers and sensors are less than a millimeter past the paper width of 8.5”. When the paper is straight, the laser is not blocked and the sensor is able to pick up the signal. When the paper is not perfectly straight, the laser is temporarily blocked and the sensor is not able to detect a signal. The sensor then sends this data to a computer which stops the next component of the printer from applying the ink to the angled piece of paper. There are sets of lasers at the beginning and end of the device, to prevent something happening after the initial set of lasers gives their reading.

In order to make sure that the paper is flat, another pair of laser systems is set up right above the height of the paper. This system works much like the previous system. If the laser is able to be picked up by the sensor, it means that there is nothing in the way and that the paper is flat. If the laser is not detected, it means that the paper is in the way and that the paper is not flat. If it is determined that the paper is not flat, the sensor sends a signal to the next component of the printer

and no ink is applied to that specific sheet. Again, there are two sets of the laser systems, one at the beginning and one at the end to prevent bending after the original detection point.

The paper must be flat and straight to make sure that the most accurate velocity measurement is obtained. To calculate velocity, we first need to determine the change in distance and the change of time. To do this, two laser detection systems are set up exactly 1.5 inches apart. Therefore, the change in distance is 1.5 inches. To determine the change in time, the device uses lasers and sensors above and below the paper path. When the paper is directly above the first laser, the detector is no longer able to sense the laser. At this exact moment, a timer is started. When the paper is directly above the second laser, the second sensor is not able to detect the laser. At this exact moment, the timer is stopped. The timer is extremely accurate to give the best reading. The time recorded is then sent to the computer, which does the following calculation to determine paper velocity.

$$Velocity = \frac{Change\ in\ distance}{Change\ in\ time}$$

$$Change\ in\ distance = 1.5\ inches * \frac{2.54\ cm}{1\ inch} * \frac{10\ mm}{1\ cm}$$

$$Velocity = \frac{1.5\ inches * \frac{2.54\ cm}{1\ inch} * \frac{10\ mm}{1\ cm}}{Change\ in\ time\ (seconds)}$$

*where change in time is determined by the laser system

This process gives a velocity measurement in mm/s. Since the accuracy of the timer process and distance is so accurately measured, the accuracy of this velocity calculation is extremely accurate. Once this value is obtained, the computer sends the information to the next component of the printer.

<u>Conclusion:</u>

Our team's final design is able to meet all of the customer requirements. By utilizing laser systems, the velocity measurement does not depend on any physical aspects of the printer or paper, such as the driver roll speed, the thickness of the paper, the diameter of the drive roll, the paper dimensions, and the finish of the paper. Therefore, the device can be used in almost every type of printing job. Due to the precision granted by lasers, the device is able to determine the velocity of paper within a tolerance of 0.25% by determining the change in distance and the change in time with the highest quality of precision. The device is able to be implemented in a multitude of locations on the paper path, and it works between two drive rolls and a baffle. Although the process may seem costly, it is required to achieve the highest quality measurements in such a high quality machine. Nearly all the components can be changed automatically to allow the device to work for a variety of paper types and sizes.

References:

"Banner IKnow Guide to Sensing: First Edition." *Bannerengineering.com*. Banner Engineering Corporation. Web. 10 Nov. 2011. <http://info.bannerengineering.com/xpedio/groups/public/documents/literature/120236.pdf>.

"How HP Measures Inkjet Printing Speed." *HP - United States | Laptop Computers, Desktops, Printers, Servers and More*. Web. 10 Nov. 2011. <http://www.hp.com/products1/inkjetprinter/printing_speed.html>.

"Photoelectric Sensors Information." *GlobalSpec*. Web. 10 Nov. 2011. <http://www.globalspec.com/learnmore/sensors_transducers_detectors/proximity_presence_sensing/photoelectric_sensors>.

"The Quick and Dirty on Photogates." *Waukesha South High School*. Web. 8 Nov. 2011. <http://www.waukeshasouth.com/physics1/photo.html>.

"Working with Ink-jet Printers." *Golden Artist Colors, Inc.* Web. 10 Nov. 2011. <http://www.goldenpaints.com/mixmoremedia/workprint.php>.

"Xerox IGen4 Digital Press: Advanced Color for Many Applications." *Xerox Document Management, Digital Printing Equipment, Business Process Outsourcing*. Web. 10 Nov. 2011. <http://www.xerox.com/digital-printing/digital-printing-press/color-printing/xerox-igen4/enus.html>.