

Vision systems for press

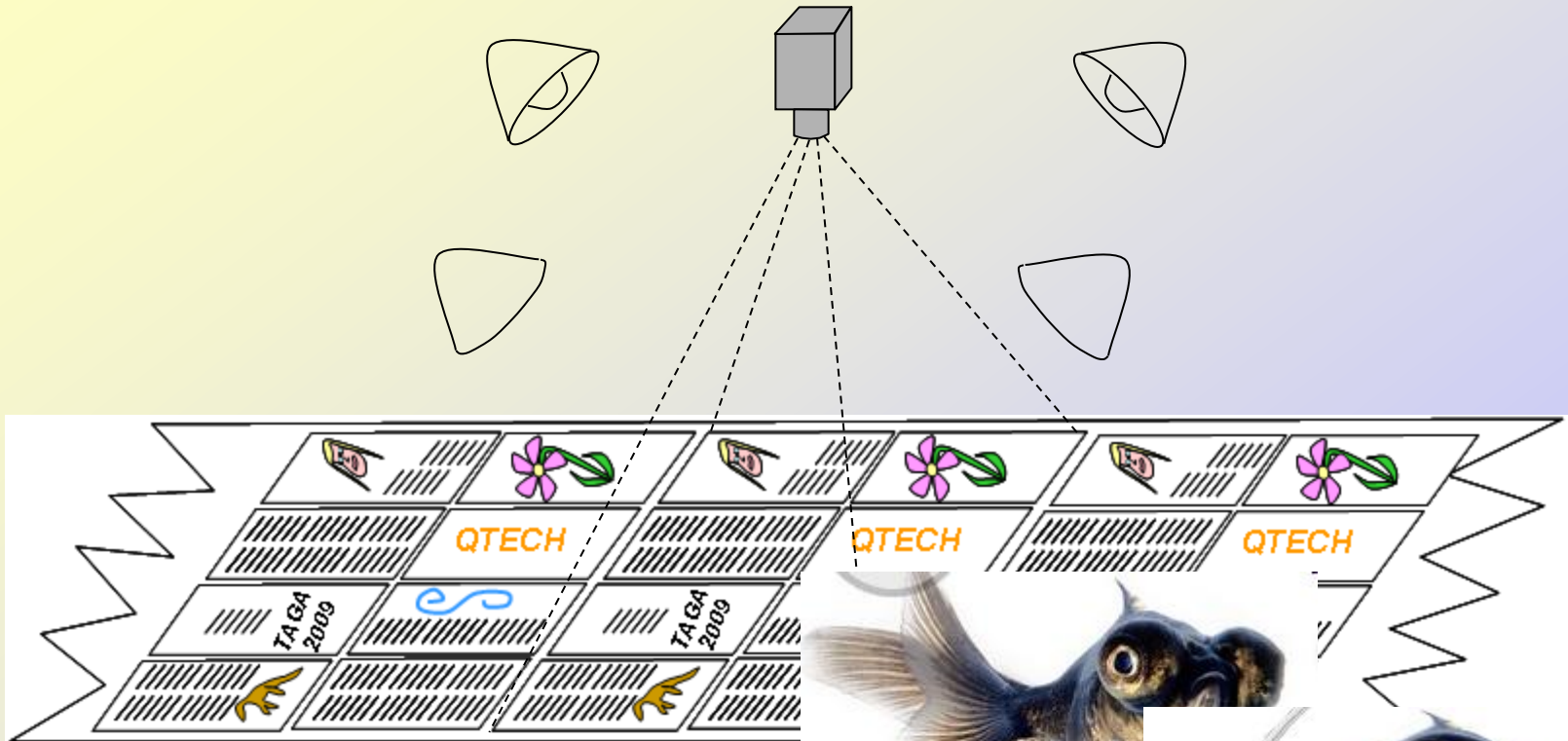
*High level
system design*

John Seymour
Principal Engineer - Research
QuadTech

Part 1

The Imager

The “Webcam”



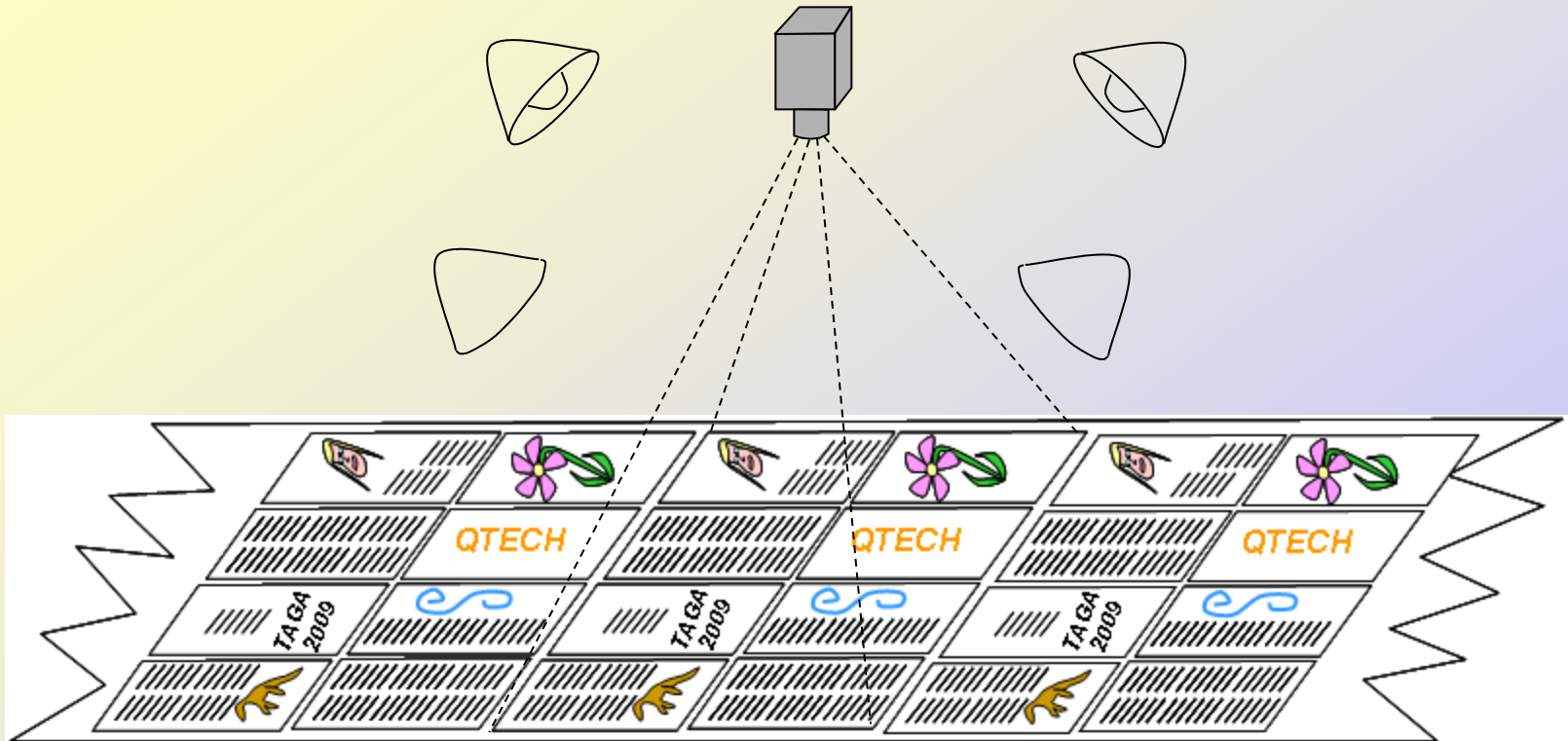
Assume we want a picture of a 40" web...
the camera should something over 40" away

John Sweeney says we could use a fish-eye lens.

But I say he's a bone head.



The “Webcam”



40 inch wide web, 2000 pixel camera → 50 DPI

The “Webcam”

50 DPI ain't so bad

... compared to midtown, due to
...," says William Wharton, an
...st who heads research at the
...or Real Estate at MIT. Sept. 11
...skewed the northern shift by the
...s and investment banks that for
...had anchored Wall Street. Inse-
...ber 9/11, many financial firms, in-
...Citigroup and J.P. Morgan Chase,
...bair employees to other locations
...he city and to nearby Jersey City.

latest plans
10 million s



'PEOP
TO INC
WITH

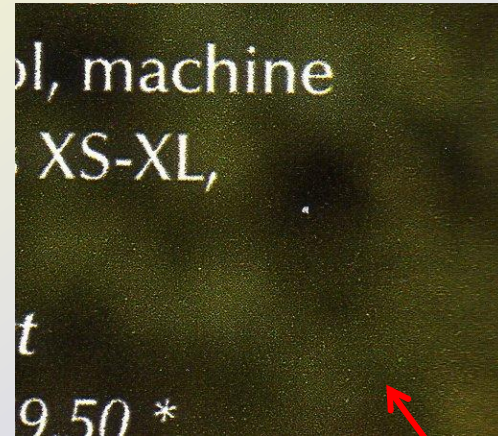
—SUSAN I



THE INSIDE BUSINESS MAY 2006

The “Webcam”

But it won't see tiny defects

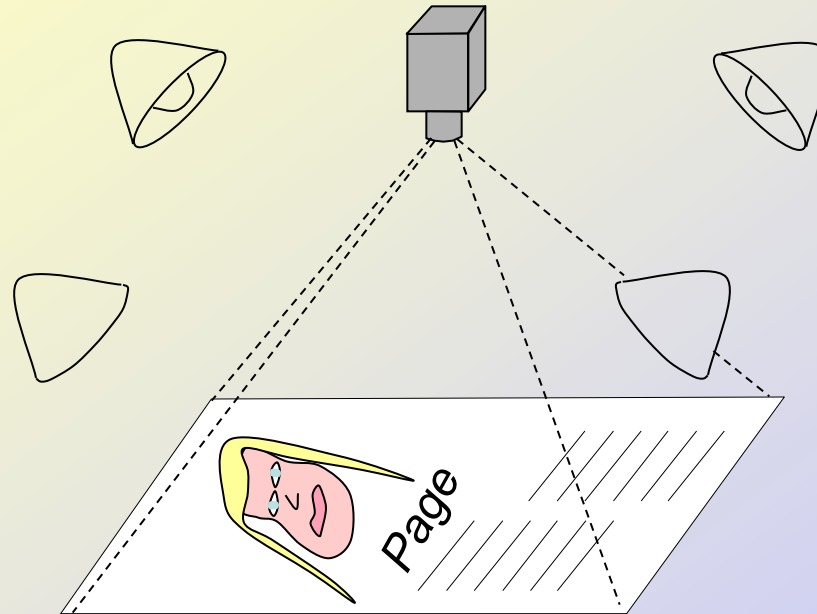


Pic of defect at 600 DPI



Pic of defect at 50 DPI

The “PageCam”



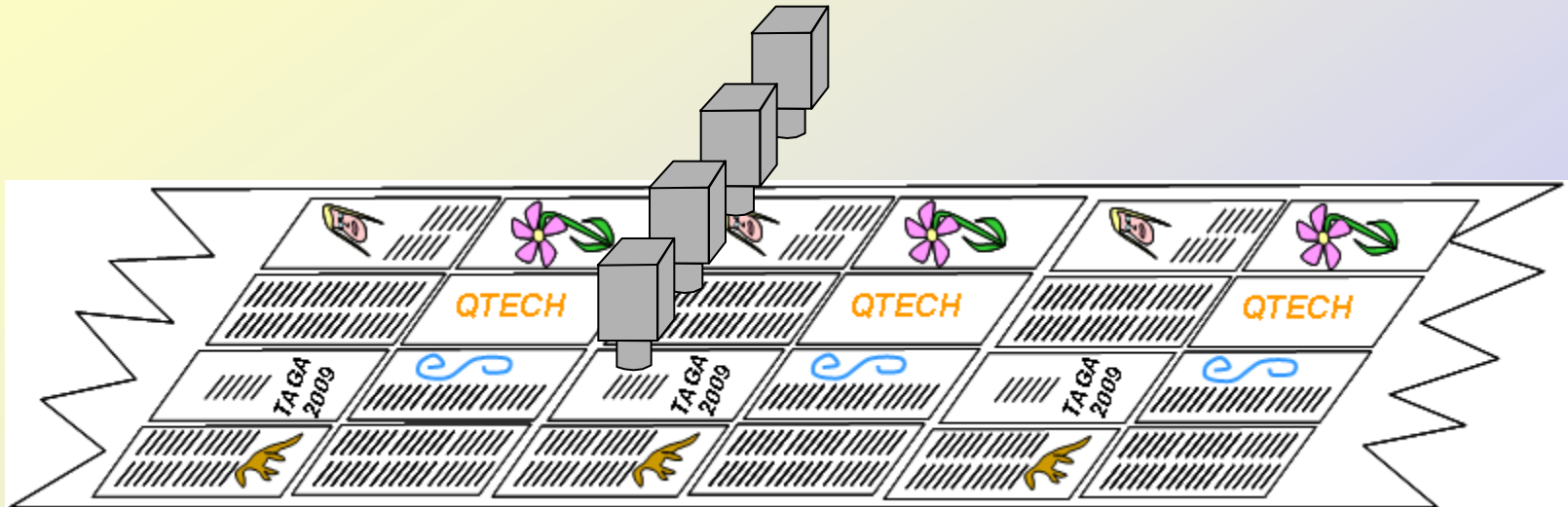
Working Distance	20 inches
Package Height	30 inches?
Resolution	~180 DPI

180 DPI means pixels are ~0.0055 inch

We need three pixels to find a defect

Minimum detectable defect ~0.017 inch

The “PageCam X 4”



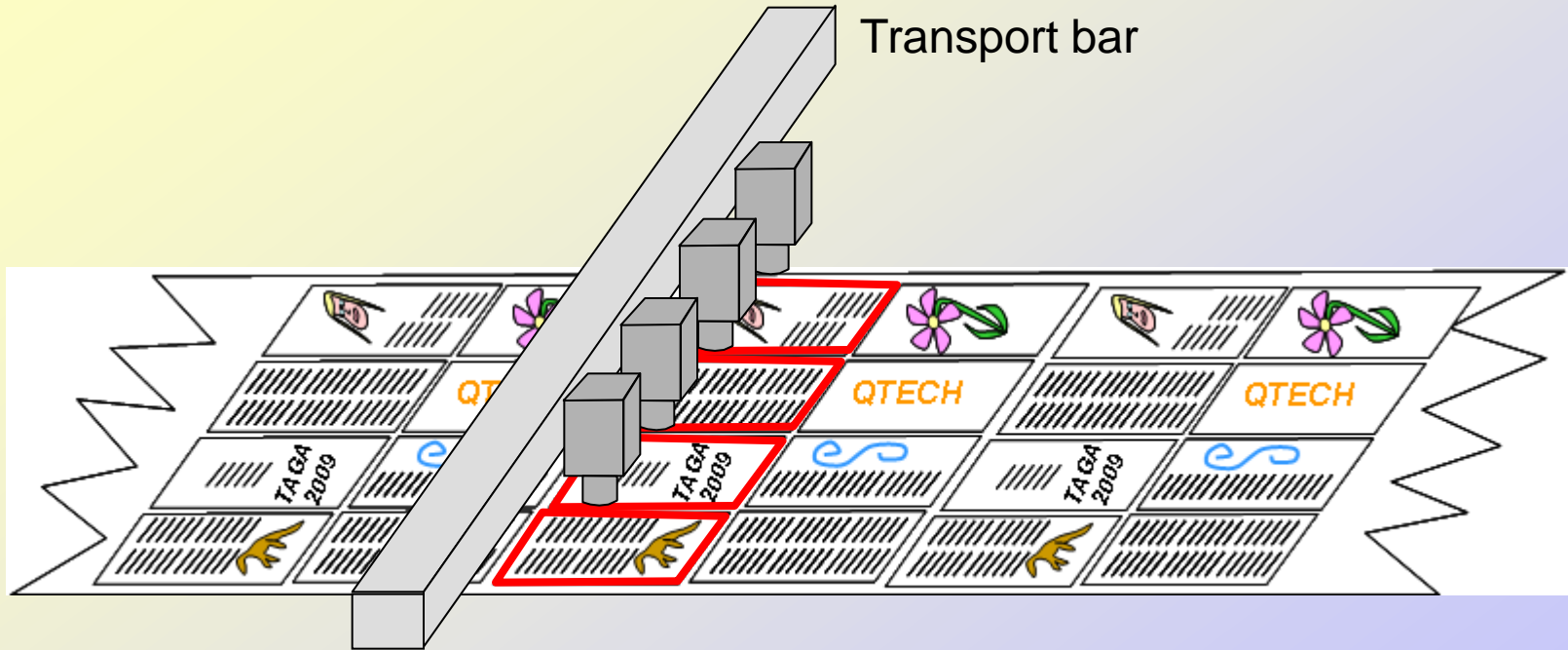
3,000 feet per min = 50 pages per second

50 frames per second is reasonable for a camera

Probably need a strobe: xenon or LED

*This could inspect
everything printed:
100% X 100%*

The “Peripatetic PageCam”

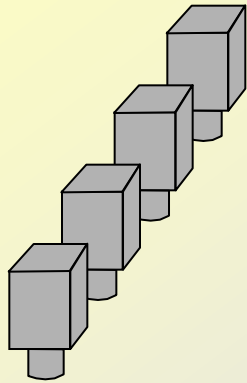


Transport is about the cost of a camera,
so this is half the cost of Pagecam X 4

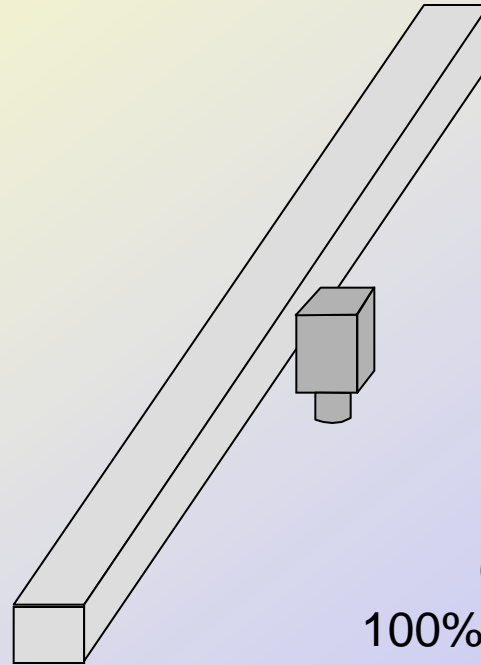
Might take 10 seconds to get across the web ~300 pages

Slower frame rate → cheaper cameras & cheaper processing

Pagecam X 4 VS Peripatetic



Can inspect
100% of an impression
100% of the impressions



Can inspect
100% of an impression
0.3% of the impressions

-- or --

Can inspect
25% of an impression
100% of the impressions

When is 100% X 100% worth the extra cost?

Is 0.3% Acceptable???!?!?!?

If the requirement
is to find all the
defects...

sampling won't
help much

If one out of a hundred
pages are out of tolerance

and we inspect only 0.3% of
those bad pages
(and discard them)

then our proportion of
acceptable product goes from
99% to 99.003%.

With this requirement, 100% X 100% is necessary.

Is 0.3% Acceptable???!?!?!?

When is “zero defects” a requirement?

If the requirement
is to find all the
defects...

sampling won't
help much

- High quality print
- Money, stamps, lottery tickets, stock certificates...
- Pharmaceutical labels
- Value added

Is 0.3% Acceptable???!?!?!?

If the requirement is to find all the defects...

sampling won't help much

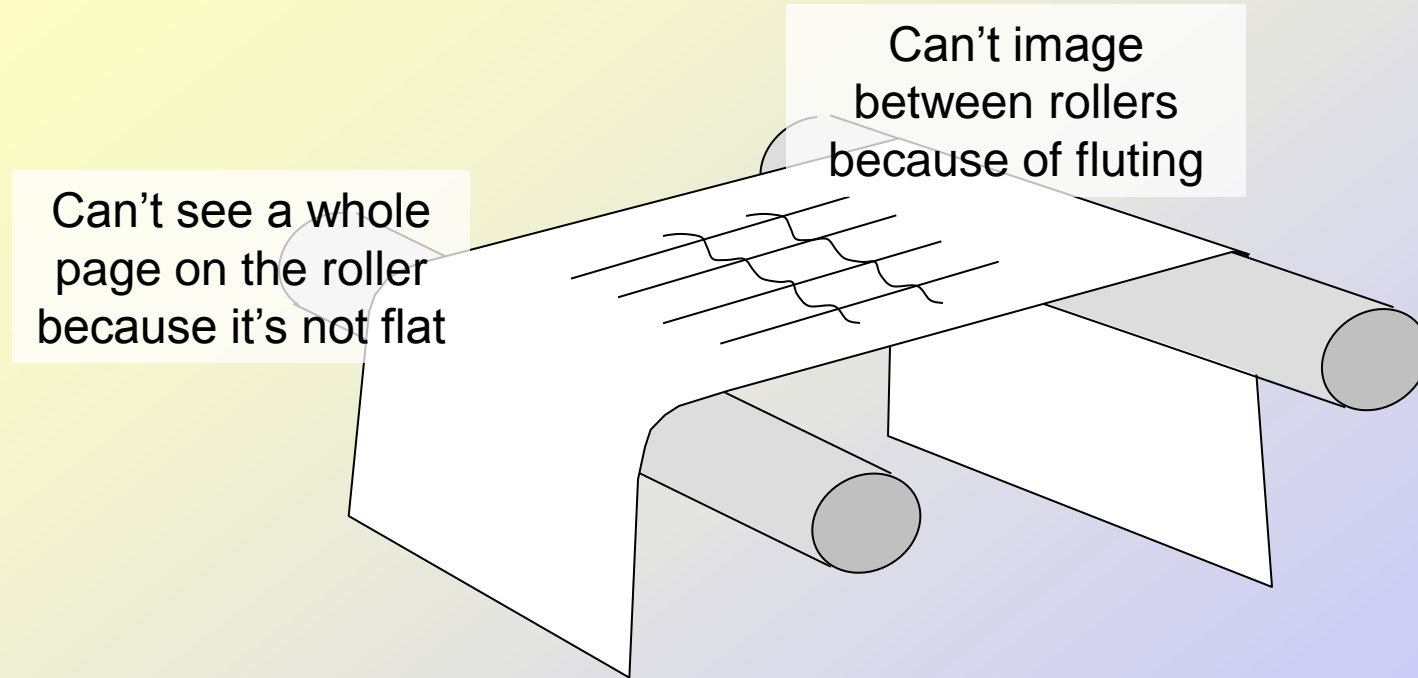
If the requirement is to make process corrections...

Sampling every 10 seconds beats human inspection

If the requirement is SPC data...

Sampling every 500 impressions is adequate

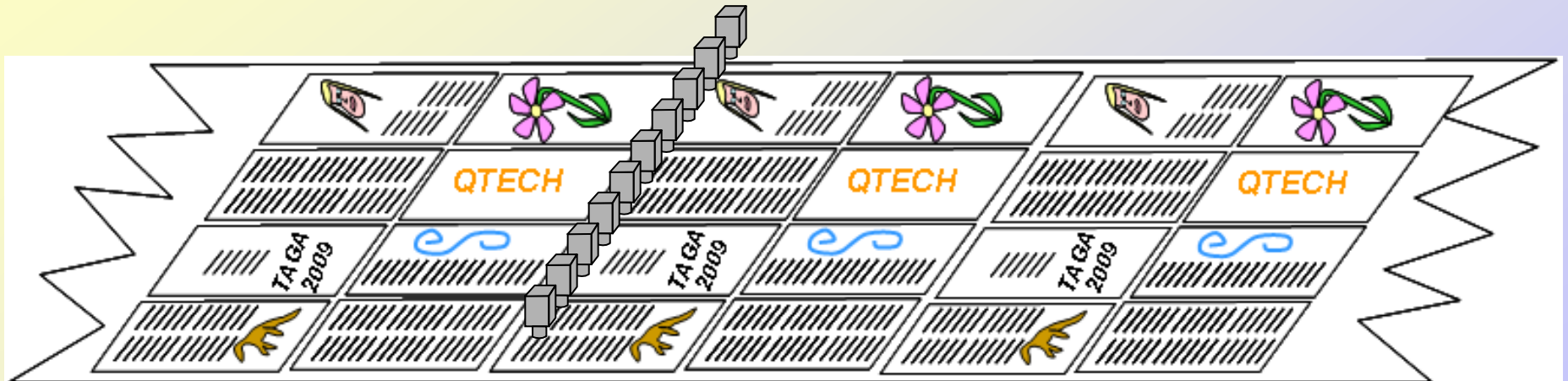
Impracticality of PageCam



From a practical standpoint, four inches is about the largest reasonable FOV.

The “Semi-PageCam X 10”

*Cameras lined up every four inches
across the web*



150 frames per second for 100% X 100% inspection (still reasonable)

500 DPI – smallest defect 0.006 inch

Ten cameras across a 40” web, and five PCs? Three?

Wow. That’s a lot of stuff.

The “Semi-PageCam X 10”

500 DPI → 0.002 inch pixels

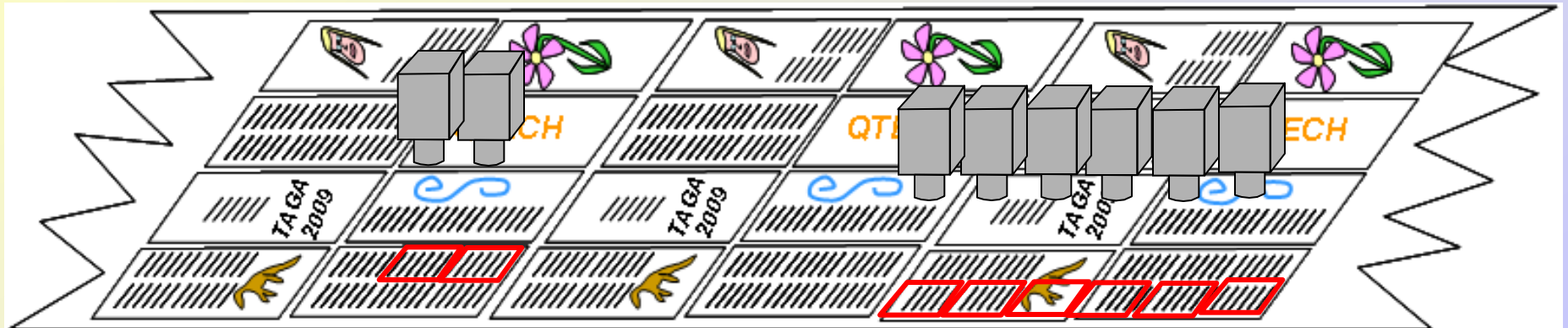
At 3000 FPM,
the web moves
0.002 inch (one pixel) in 3 μ sec.

Exposure time (at 3000 FPM) is **3 μ sec**

This is getting tough!

150 frames per second for 100% X 100% inspection (**still reasonable?**)

The “Gypsy Semi-PageCam”



“Four inch FOV” options

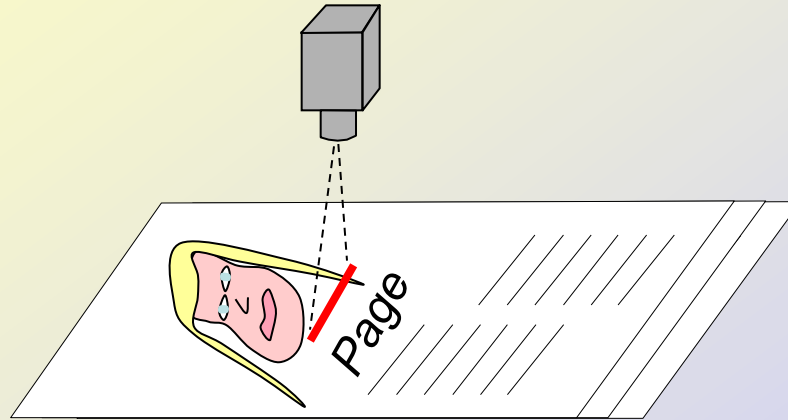
	Multicamera	One camera
Number of cameras	10	1
Number of PCs	5	1
Number of transport bars	0	1
Number of impressions required to get an image of a full impression	1	~1000
% inspected	100%	0.1%

15 pieces

3 pieces

Linescan camera

An image of a line
is captured at one
position.



The web moves
and an image of
the next line is
recorded.

The web moves
again and a third
image of a line
is recorded.

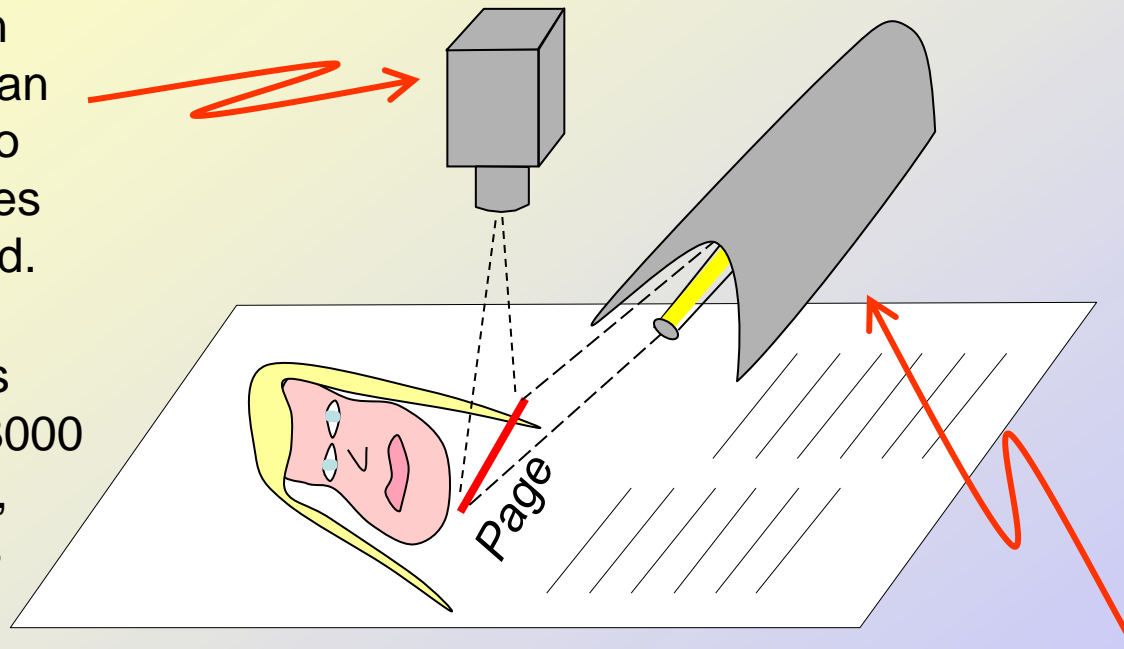
Why linescan?

- Continuous lighting
- Less area to illuminate
- Easier to stitch images together
- Easier to image a flat surface
- A wide field of view is more practical

Linescan camera

Linescan cameras can read up to 70,000 lines per second.

This means 117 DPI on a 3000 FPM press, continuous

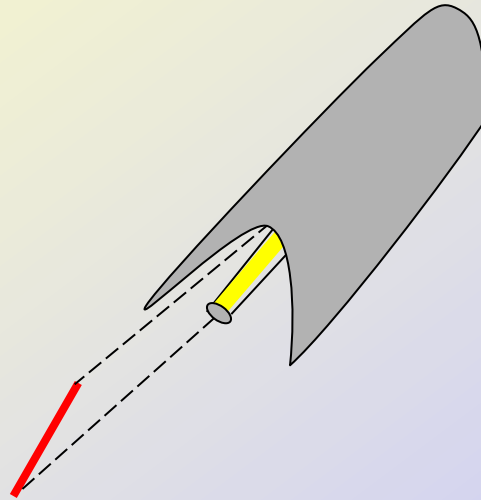


Too fast for strobe lighting...
Could be incandescent, fluorescent, or LED.

Linescan illumination

Short “exposure” time (14 μ sec)
means
lots of light required.

Lots of light
means
lots of heat dissipation required.



~~Convection cooling? Fans, water cooling?~~

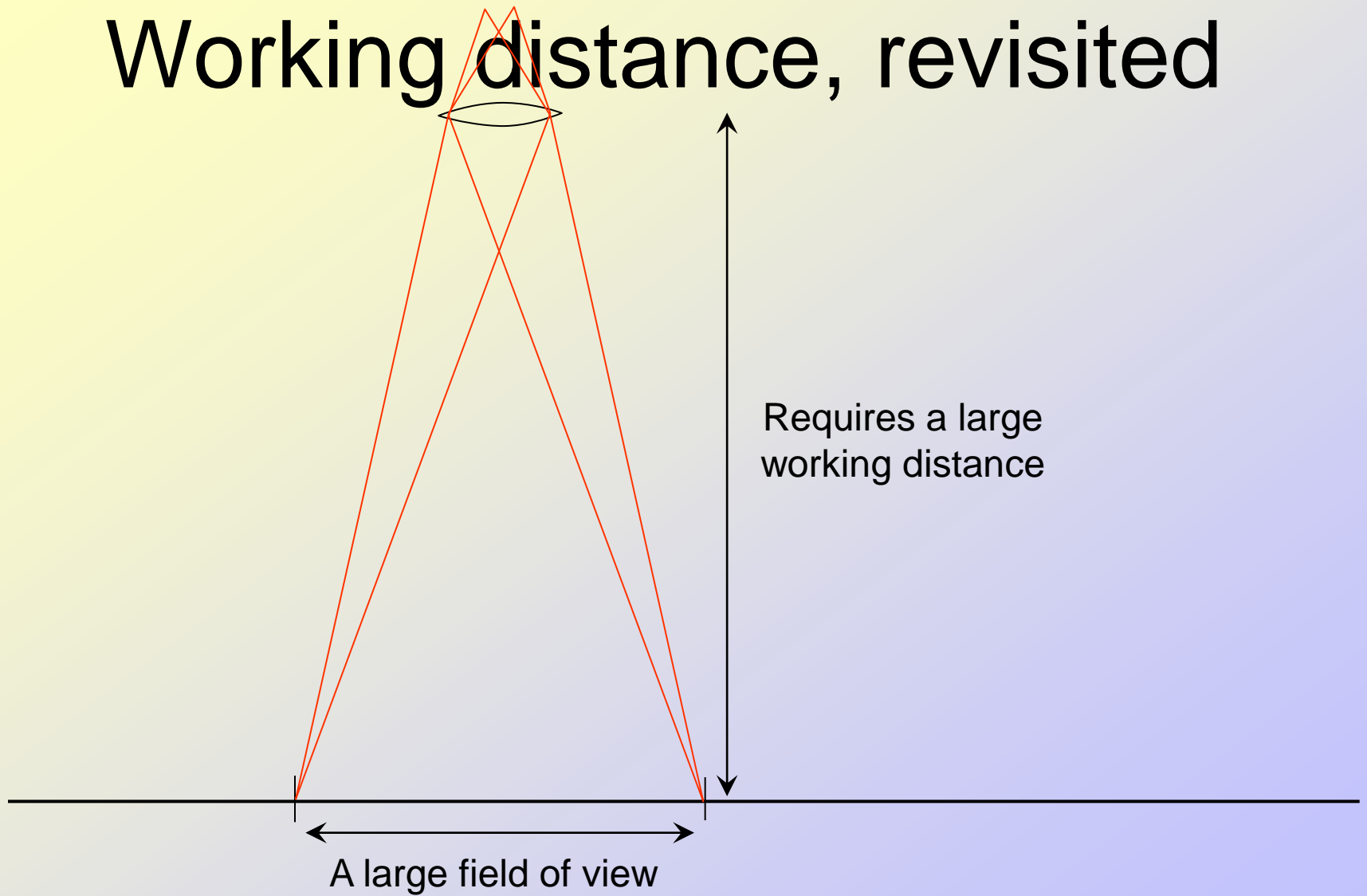
Too fast for strobe lighting...
Could be incandescent,
fluorescent, or LED.

Why linescan?

- Continuous lighting
- Less area to illuminate
- Easier to stitch images together
- Easier to image a flat surface
- **A wide field of view becomes practical**

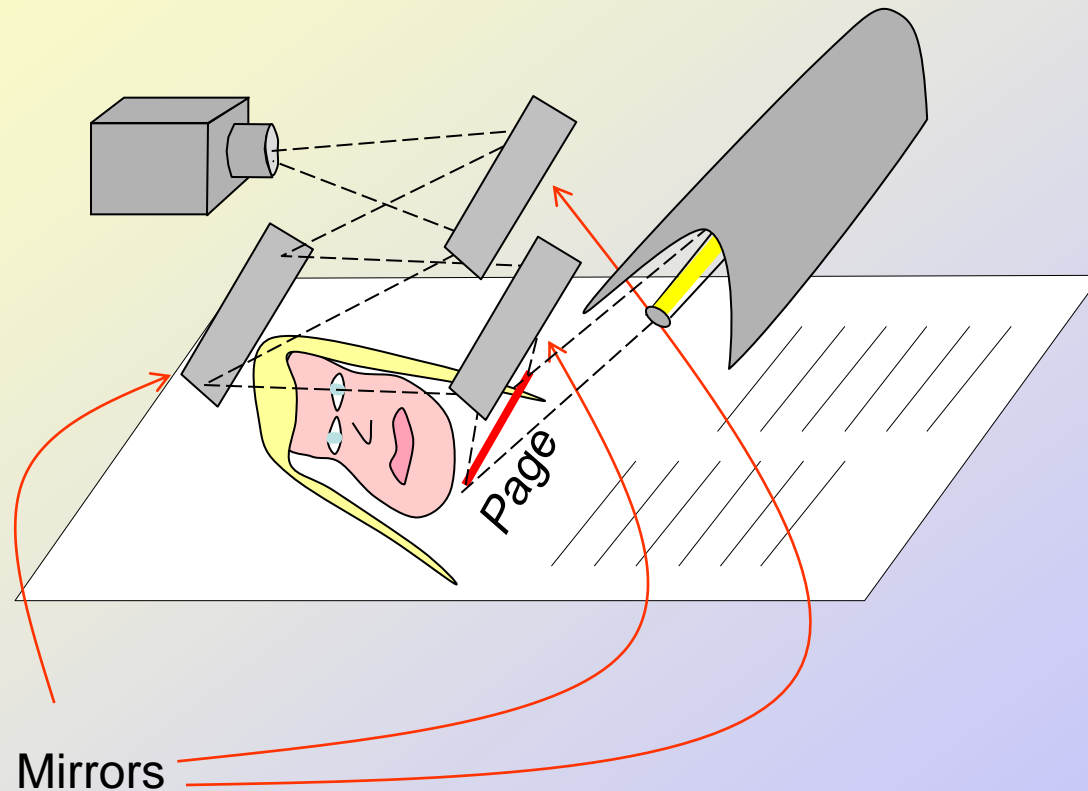
How can a linescan camera help us
image a wider part of the web?

Working distance, revisited



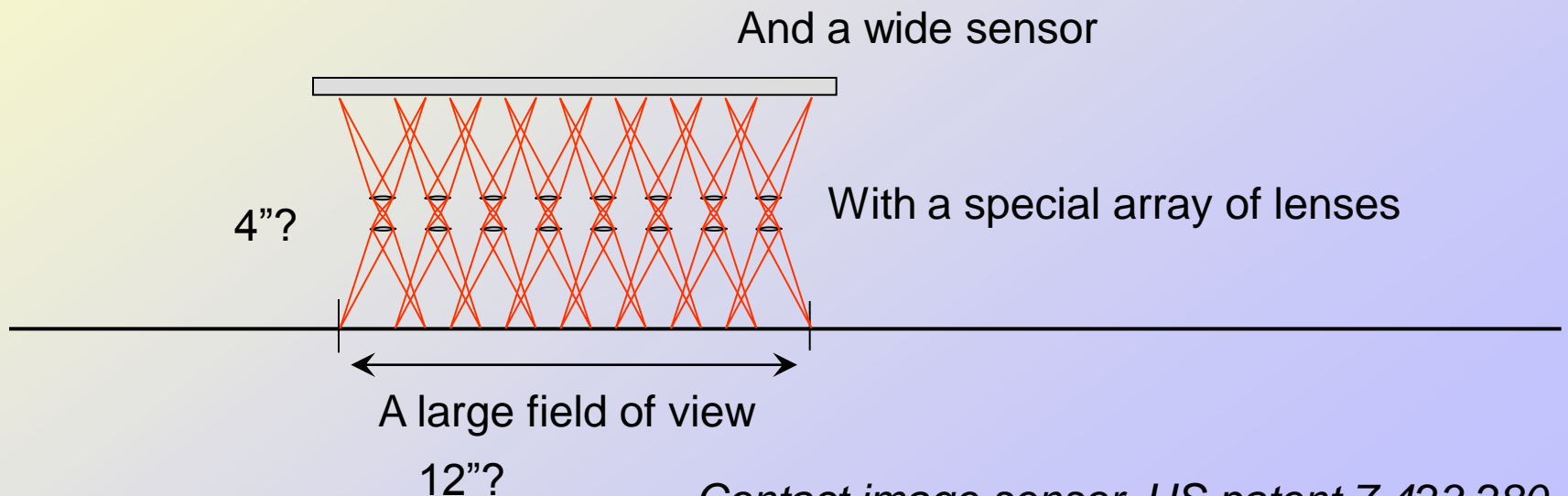
Working distance, revisited

With a narrow field of view, folded optics are practical



Working distance, revisited

It is possible to image
a very wide (but narrow)
area at a small working distance.



*Contact image sensor, US patent 7,423,280
and US application 20080289528*

Summary of imagers

- Area sensor
- Long working distance linescan
- Contact image sensor

Summary of imagers

	Area sensor	LWD linescan	Contact image sensor

Summary of imagers

	Area sensor	LWD linescan	Contact image sensor
Lighting	Strobed	Continuous	Continuous

Summary of imagers

	Area sensor	LWD linescan	Contact image sensor
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Transport	Yes	No	Maybe

Summary of imagers

	Area sensor	LWD linescan	Contact image sensor
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Transport	Yes	No	Maybe
Size	Moderate	Large	Small

Summary of imagers

	Area sensor	LWD linescan	Contact image sensor
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Image size	4" X 4" at a time	Entire web	12" wide, continuous

Summary of imagers

	Area sensor	LWD linescan	Contact image sensor
Lighting	Strobed	Continuous	Continuous
Transport	Yes	No	Maybe
Size	Moderate	Large	Small
Image size	4" X 4" at a time	Entire web	12" wide, continuous
Cost	Cheapest	Most expensive	Moderate

Part 2

What to do with the images?

What to compare against?

- Prepress image
- OK sheet image
- Previous sheet

Makeready verification

Best for long term
changes in the press run

Best for catching short term
changes, as opposed to drift

Uniform intensity

Inspection of unprinted material

Unpatterned inspection

The camera looks at the web
before it's printed.

Inspect stored images
after a web break

Return on investment:
Rebates from paper mill

What if there is a defect?

Ideal system

Diagnosis and repair

If a hickey is found in a critical area,
kick in the divert gate
and issue a blanket wash.

If there is a dry up, then
adjust the water.

If a scratch is found on the plate,
then send a text message to the
plate room and automatically
mount the new plate.

What if there is a defect?

Diagnosis and repair

Harry Quadracci had a
vision of the
“lights out” pressroom*.

*2001 R&E Council Pressroom Conference

What if there is a defect?

The “lights out” press
is run by
one person and a dog.

The person is
needed
to feed the dog.

The dog is needed to
keep the person from
touching the press.

We're not there yet!

What if there is a defect?

Almost ideal system

Diagnose and tell
the press operator

Dave, excuse me for bothering you. I know you don't normally worry about hickeys in the work, but there is a particular hickey that just showed up, and it happens to be in the middle of the bumper on that one important car ad. You know how much that customer complained at the last color ok. Perhaps you might have a look at it?

We're not there yet!

Categorize as streak, blob, color shift,
big defect or small

What is a defect?

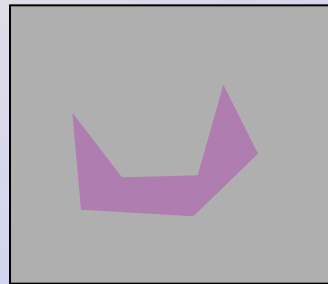
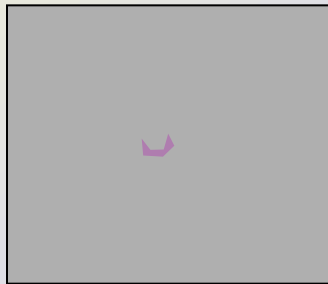
Which
imperfection
is a defect?



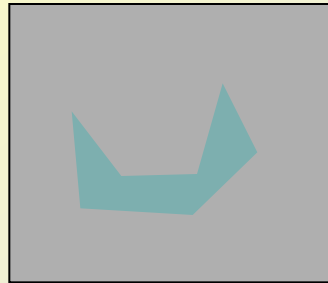
*Are we selling
flowers,
cosmetics, or
clothes??*

What is a defect?

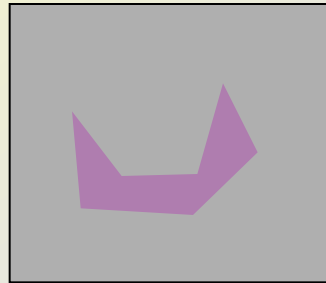
- A single pixel way out of tolerance
- A single pixel moderately out of tolerance in a critical area
- A big, contiguous group of pixels mildly out of tolerance



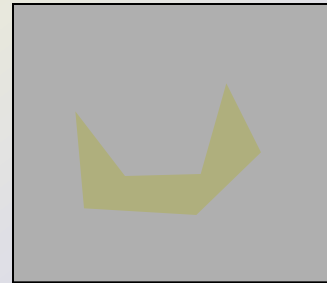
What is out of tolerance?



Red down 50



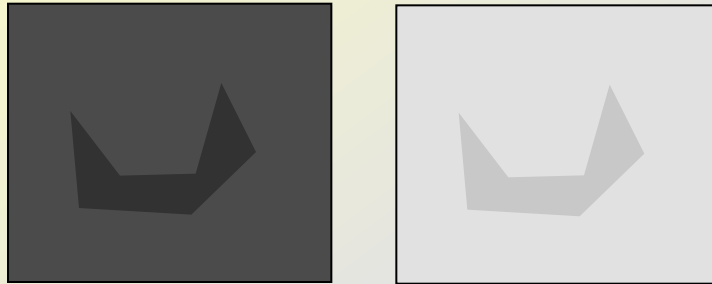
Green down 50



Blue down 50

Gray value changes are not all created equal

What is out of tolerance?



All down 25

Gray value changes are not all created equal

*Ideally, tolerances should be set colorimetrically
(as a ΔE and not a ΔRGB)*

What if there is a defect?

Realistic system

Identify defective pixels, and...

- Flip the divert gate
- Alert press crew
- Log the error

What if there is a defect?

- Flip the divert gate
- Alert press crew
- Log the error

*Why should I spend money
to install a system that
increases my waste?*

What if there is a defect?

- Flip the divert gate
- Alert press crew
- Log the error

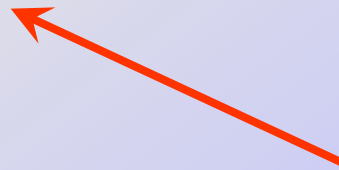
*Greater chance
of bad product
sent to bindery*

Industry trends

- Wider presses
- Higher speed
- More automated
- Smaller crews



Less human
inspection



What if there is a defect?

- Flip the divert gate
- Alert press crew
- Log the error

Store a digital copy of every image?

100 DPI, 40 inch web, 1500 impressions / min
= about 2 ½ Terabyte / hour

Store a digital copy of every image?

Error at impression 14,237, x = 14.02", y = 34.61"

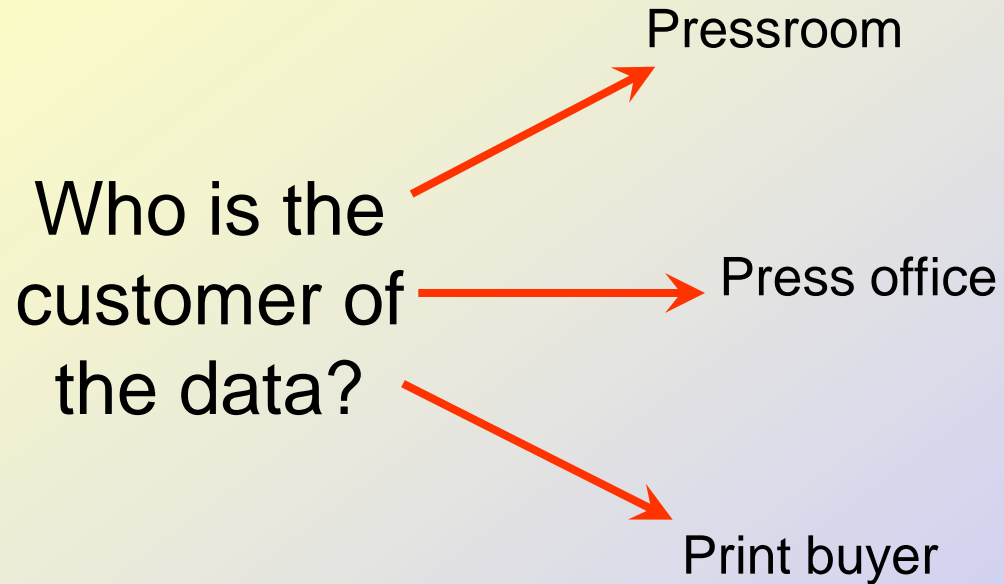
Error at impression 14,237, x = 14.03", y = 34.61"

Error at impression 14,237, x = 14.02", y = 34.62"


...

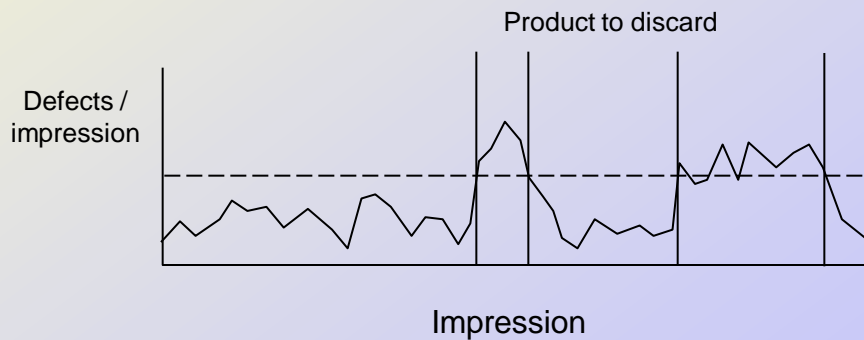
Not very useful either.

Logging defects



Logging defects

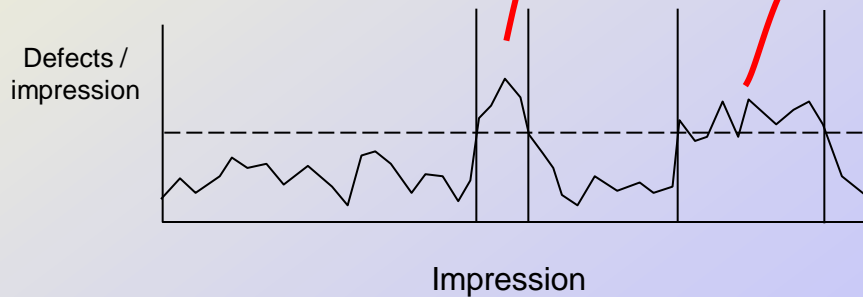
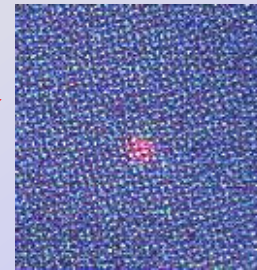
- Who is the customer of the data?  Pressroom
- Bad product alert
 - Inspection for roll – roll
 - “Roll” map



Logging defects

Who is the customer of the data?

→ Press office



Logging defects

Defending against rebates:
99.62% of the impressions had less than six minor defects

Who is the
customer of
the data?  Press office

Logging defects

Asking for rebates:
0.38% of the impressions had six or more minor defects

Who is the
customer of
the data?



Print buyer

Did someone say
CIELAB?

Uh-oh

*Ideally, tolerances should be set colorimetrically
(as a ΔE and not a ΔRGB)*

Accurate CIELAB w/ RGB cameras

Summary of Seymour's 2009 TAGA paper

*An RGB camera
can monitor color,
but can't measure
color.*

Accurate CIELAB w/ RGB cameras

Issues with accuracy

- Bit depth
- PMZ calibration
- Nonlinearity
- Scattered light
- Non-uniformity across the image
- Variability in lighting intensity
- Goniophotometric concerns
- Spectral response
- Backing material

Accurate CIELAB w/ RGB cameras

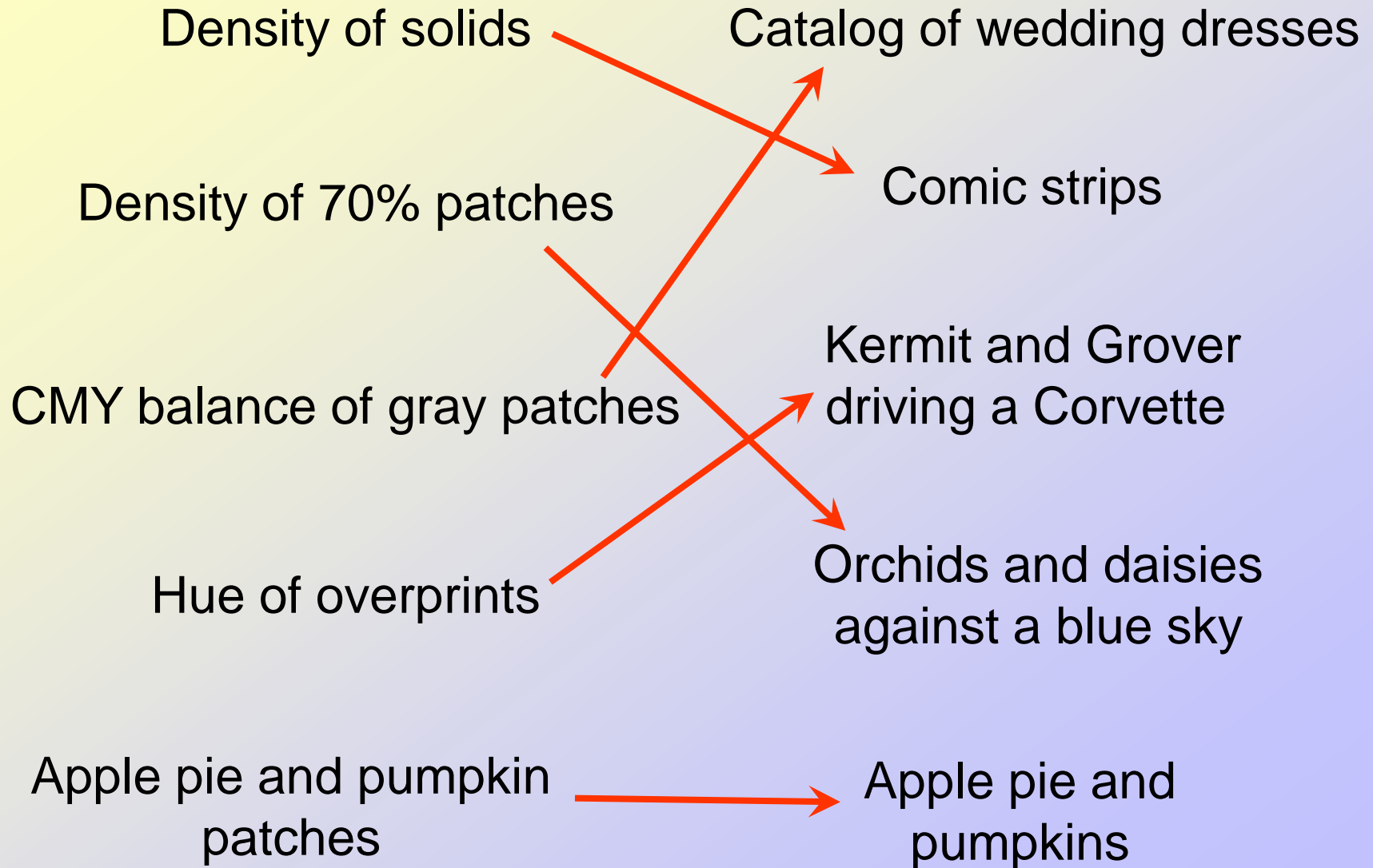
The two most difficult

- Bit depth
- PMZ calibration
- Nonlinearity
- Scattered light

These need to be designed in from the start

- Goniophotometric concerns
- Spectral response
- Backing material

Color control in the work



Color control in the work

If we have an image of the work, why bother controlling the color bars?

If we have:
accurate CIELAB from the imager,
and a prepress target image ...

We can do *makeready* CCIW

If we have figured out how to
move the ink keys

If we have:
A carefully designed RGB imager

We can do CCIW in the run

If we have figured out how to
move the ink keys

Summary

There are several practical designs for an on-press vision system.

1. Area sensor
2. Long working distance line scan
3. Contact image sensor

Each with strengths and weaknesses.

Summary

Inspection of
unprinted web



Rebates
from the mills

Summary

Inspection of
printed web



When 99.9% just isn't
good enough

Alert press crew
Process control data
Rebate arguments

Summary

Identifying defects is not as simple as it may seem

Area of continued development

CIELAB will help

Summary

Web inspection systems
can be used for color
control of the work

*Thank you for
your attention!*

John Seymour
Principal Engineer - Research
QuadTech