

**15 years of ~~Mistakes~~  
Lessons in Image  
Management at  
Mayo Clinic**

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# Disclosures

- ◆ Licensed technology to
  - ◆ TeraMedica (DICOM Archive)
  - ◆ GE
  - ◆ Siemens
- ◆ NIH, EU funding
- ◆ I am a #&^Q!\$ radiologist...
- ◆ but also an informaticist 😊

# Organization

- ◆ A bit of history
- ◆ Lessons learned along the way

“Men are so willing to respect anything that bores them.”  
— Marilyn Monroe

# History of PACS at Mayo

- ◆ 1993—Pilot of Siemens, GE, LORAL
- ◆ 1994—LORAL selected (except ultrasound)
- ◆ 1996—GE buys LORAL
- ◆ 1998—GE “end of life’s” the LORAL product line in favor of COTS-based PACS
- ◆ 2001—Mayo selects Siemens PACS
- ◆ 2009—Mayo selects GE PACS

# History of RIS at Mayo

- ◆ 1991—Mayo announces co-development of RIS with ADAC Systems
- ◆ 1995—ADAC decides to abandon QuadRIS line and develop new RIS
- ◆ 1997—RIS fully implemented

# History of Enterprise Imaging at Mayo

- ◆ 1986—Mayo opens Mayo Jacksonville
- ◆ 1987—Mayo opens Mayo Scottsdale
- ◆ 1992—Mayo Health System (now 70 sites)
- ◆ 1993—MCJ selects Siemens PACS
- ◆ 1996—MCA selects GE PACS

All 3 sites use RIMS, but slightly different versions  
(different HIS, billing rules at each site)

# History of Digital Image Distribution at Mayo

- ◆ 1993 PACS model ('dumb' rad wkstn) not viable
  - ◆ simplest workstation was \$30,000
  - ◆ 1200 exam rooms \* \$30,000 = \$36,000,000.
- ◆ 1995—early version of lightweight clinical image viewer developed
- ◆ Rolled out to 15,000 workstations across Mayo by 2001
- ◆ 2005—true web/java client
- ◆ All patient digital images & video, not just radiology

# The “Lessons” Learned

I learned to walk as a baby and I haven't had a lesson since  
--Marilyn Monroe



# Lesson 1: Get Workflow Right

- ◆ Its like real estate: workflow, worfklow, workflow!

# Imaging Workflow

- At the 1998 SCAR Meeting:

PACS is like Teenagers & Sex:

- Everybody is *talking* about it

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# Imaging Workflow

- Today, most radiology products (correctly) emphasize *workflow*

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# Imaging Workflow

- Today, most radiology products (correctly) emphasize workflow

**WORKFLOW** is like Teenagers & Sex:

- Everybody is talking about it
- Many say they are doing it
- Few if any are doing it
- No one is doing it well

# Lesson 1: Workflow!

- ◆ System must support the practice
  - ◆ How the product designers think you work and to a lesser degree, how you implement it, *will* define how you work
  - ◆ See it in action at other places
  - ◆ Prototype/test it before you accept/pay for it. Its the things that are missing that kill you

The trouble with censors is they want to see if the girl has cleavage. They ought to worry if she hasn't any.

--Marilyn Monroe

# Lesson 1: Workflow

- ◆ Make it easy to communicate the important points to your customers
  - ◆ Efficiently capture the findings
  - ◆ Clinicians will expect to see images (just like radiology), but unless you help them, they probably won't understand all they see.

“It takes a smart brunette to play a dumb blonde”

— Marilyn Monroe

# Lesson 1: Workflow

- ◆ Don't forget customer's workflow
  - ◆ May be a colleague, may be a patient
  - ◆ Study the use first, and then define functionality
  - ◆ Promote interaction with them
  - ◆ They need help with their workflow to be efficient

The truth is, I've never fooled anyone. I've just let them fool themselves.  
--Marilyn Monroe

# MultiMedia / Annotations

- ◆ Sex Sells
- ◆ Nothing is sexier than images with multimedia and interactivity
- ◆ Quantitative imaging and synoptic reporting drive need for connection to images (annotation)

# Lesson 2: Ergonomics

- ◆ Going digital is NOT just reading off a computer

If I'd observed all the rules I'd never have gotten anywhere.”  
— Marilyn Monroe

# Lighting

- ◆ Was a BIG issue in early days of PACS
- ◆ Modern high luminance LCDs have made this problem go away
- ◆ DICOM standard for monitors helps to assure monitors OPERATE at proper luminance
- ◆ They DO lose brightness, so can't "set and forget". Watch out for COTS!

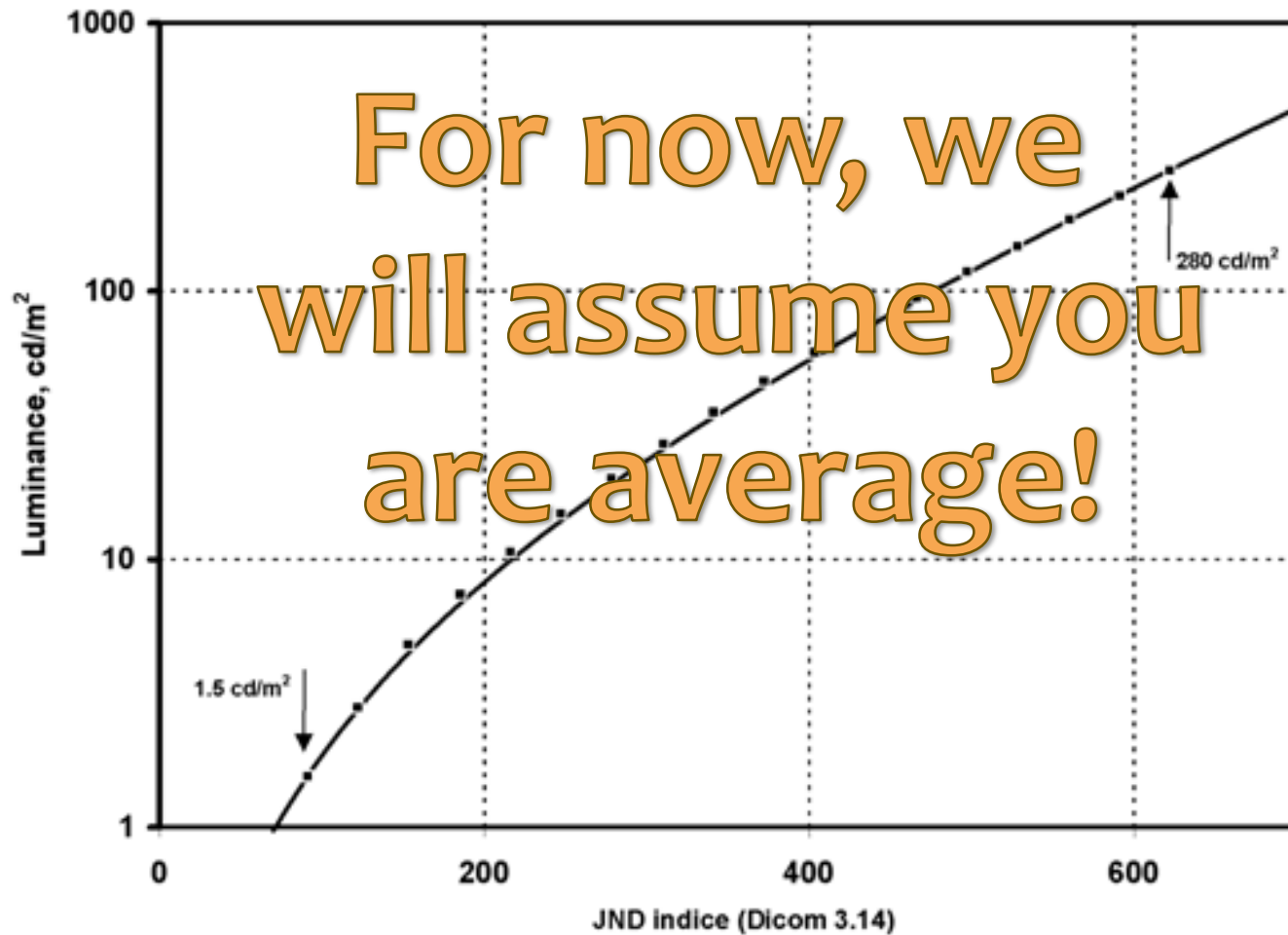
# Resolution

- ◆ Most people focus on spatial resolution
  - ◆ Its easy to understand and quote megapixels. It is harder to explain luminance and noise.
- ◆ Contrast resolution and brightness are also very important
  - ◆ Several studies have shown low noise and high contrast 'overcomes' lower resolution

# DICOM Calibration

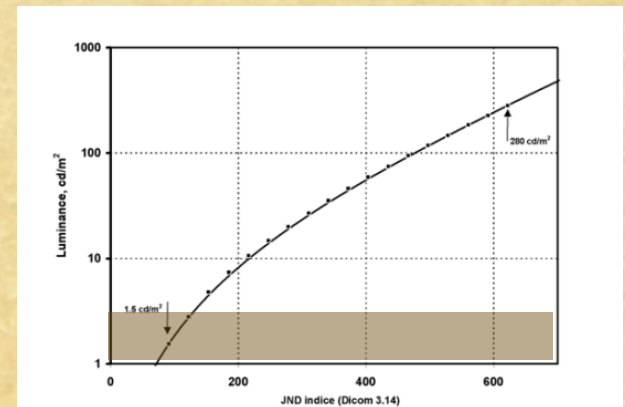
- ◆ DICOM has defined a performance standard for interpretation monitors
- ◆ Specifies a minimum maximal luminance
- ◆ ‘Perceptually linear’

# DICOM/Barton Linearization



# Ambient Light

- ◆ As ambient light levels increase, radiologist performance decreases
  - ◆ Fatigue
  - ◆ User of workstation tools
  - ◆ Interpretation accuracy
- ◆ Ambient light too low is also a problem
- ◆ You need ‘just right’ amount. Monitors are calibrated to ambient light



# Glare

- ◆ Thoughtful placement of lighting within reading room
- ◆ Dimmable indirect lighting fixtures
- ◆ Dimmable narrow beam task lighting

# When you feel tired...

- ◆ Stop
- ◆ ***Radiologists' performance decreases significantly*** after a long day of reading clinical images.
- ◆ Eyes are significantly less able to focus after a long day of reading compared to before a day of reading. This ***reduced ability to focus*** especially at long distances is known as ***asthenopia***.

# Remember to clean the Screen!

- ◆ I do this <nearly> every AM
- ◆ Sometimes, screens are noticeably dirty
- ◆ Most often now, very clean
- ◆ Technique:
  - ◆ Rooms should have cleaner
  - ◆ Wipe side to side **LIGHTLY**
  - ◆ Don't touch with fingers
  - ◆ Clean dust at edges last

# Challenge:

# Ergonomics

- ◆ Acoustics
- ◆ Temperature
- ◆ Workstation ergonomics



# Acoustics

- ◆ Considerations in Room Design
  - ◆ Isolate workstations in cabinet
  - ◆ Room / door positioning away from workstation
  - ◆ Speech recognition creates noise for others, needs low noise environment
- ◆ Acoustic dampening devices/materials
  - ◆ Walls vs cubicles
  - ◆ Workstation positioning
  - ◆ White boards vs cork boards

# Temperature/Ventilation

- ◆ CPUs with powerful graphics cards commonly draw/dissipate 800 Watts
- ◆ We have: PACS + EMR + CAD = 2000 watts
- ◆ That is more than an electric heater!
- ◆ Heat containment/control is important

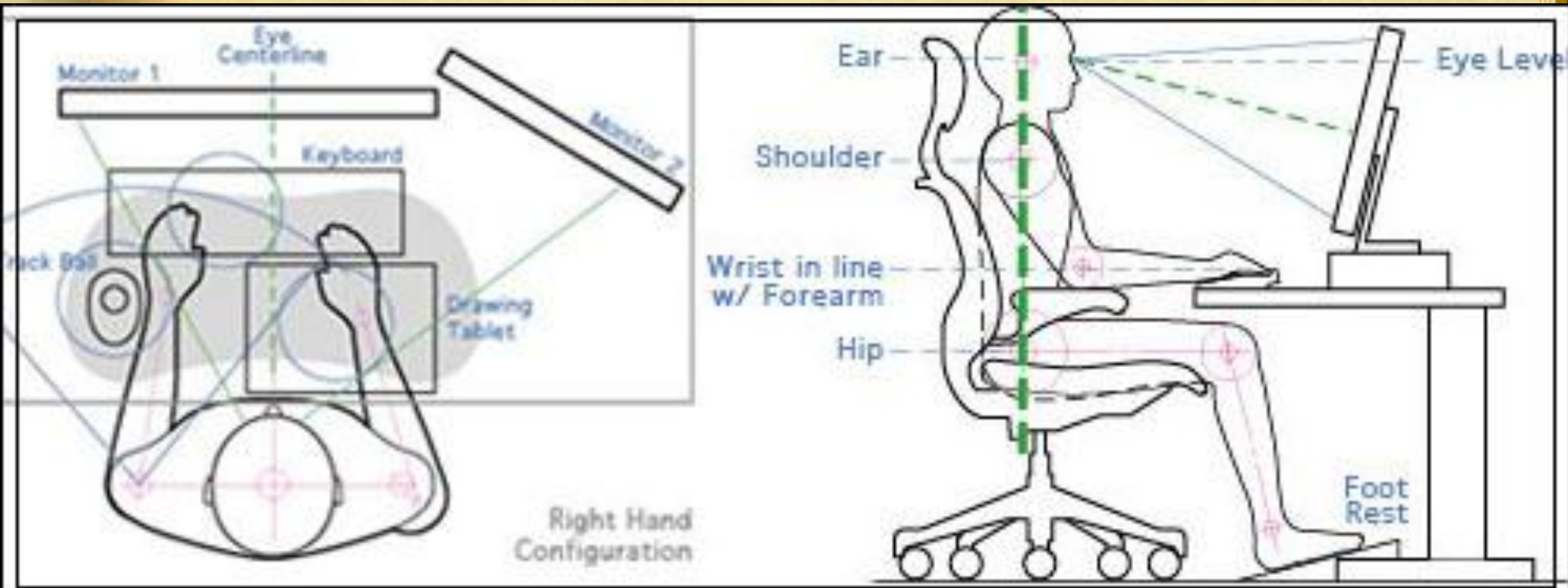
# Workstation Ergonomics

- ◆ We are not all the same size
- ◆ Need adjustable keyboards/monitors, and need to *adjust them*
- ◆ Need adjustable chairs with lumbar support and need to *adjust them*
- ◆ Improper ergonomics results in:
  - ◆ Eye strain
  - ◆ Fatigue
  - ◆ Low back pain
  - ◆ Occupational repetitive stress disorders

# Ergonomics Recommendations

- ♦ Primary deficiencies in ergonomics determined by industrial hygienist consultation
  - ♦ Chairs – should have adjustable height/armrests with lumbar support
  - ♦ Keyboards – should be adjustable in height/position with keyboard trays  
(Lincoln et al. Am J Prev Med 2000;18:37-50)

# Proper Workstation Position



# Challenge:

## Fixed gaze

- ◆ With PACS / EMR, the information is moved to the screen, rather than us changing our gaze.
- ◆ Like any muscle, failing to move from a position tends to fix it there

# Reminder Apps

- ◆ There are applications that remind you to take breaks (I like “Big Stretch Reminder”)
  - ◆ 20-20-20 rule: Every 20 minutes look at something at least 20 feet away for 20 seconds
  - ◆ My modification: Every 25 mins, take 5 minutes, get up and walk around, stretch every and get a glass of water.

# Challenge:

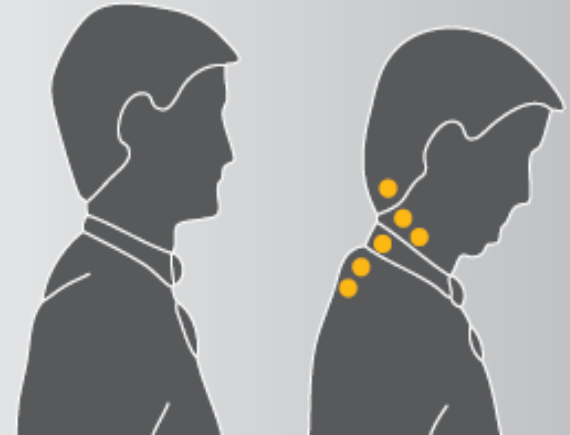
## Limited Motion

- ◆ Film / chart interactions demanded large body motions
  - ◆ Hanging films (slides)
  - ◆ Grabbing charts/discarding completed

# **You need to get up and move!**

- ◆ Just as your eyes need to be ‘stretched’ every few minutes, so do the rest of your muscles

# Stretches—30 secs each-do it!



# What about Standing Desks?

- ◆ All Mayo motorized workstations can adjust up to standing height
  - ◆ Allows for easier ‘stretch’ motions
  - ◆ May also encourage more brain attention activity

# Sitting versus Standing

- ◆ Sitting Bad
  - ◆ Sitting most of day negates benefits of regular exercise \*ACS
  - ◆ Sitting >6 hr/day -> 18% greater risk of dying from diabetes heart dz vs <3hr/day \*Am J Epidemiology
  - ◆ People who sit most of the day are 54% more likely to die from AMI \*Pennington Biomedical Research Ctr

# Sitting versus Standing

- ◆ Standing Bad
  - ◆ 9x risk of carotid atherosclerosis (BP)
  - ◆ 4x risk of varicose veins
  - ◆ Performance of fine motor tasks poorer
  - ◆ Greater risk of carpal tunnel

\*A Hedge

# Either way...



# Lesson 3: Get Your Terminology Right

- ◆ The easiest time to define and implement terminology is at the start.

“Ever notice how 'What the hell' is always the right answer?”

— Marilyn Monroe

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- ◆ The easiest time to define and implement terminology is at the start.
- ◆ Until you talk about it, you may not appreciate the subtle but important differences that exist

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# Lesson 3: Get Your Terminology Right

- ◆ The easiest time to define and implement terminology is at the start.
- ◆ Until you talk about it, you may not appreciate the subtle but important differences that exist
- ◆ Money drives everything
  - ◆ Start with billing and work backward

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# Lesson 3: Get Your Terminology Right

- ◆ Look at ALL your terminology
  - ◆ Anatomy—of course
  - ◆ Procedures
    - ◆ Helps if you want to get paid...
    - ◆ Helps if you want to share work
    - ◆ Helps if you want to benchmark
  - ◆ Workflow ([SIIM.org/TRIP](http://SIIM.org/TRIP))

“Ever notice how 'What the hell' is always the right answer?”

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# Lesson 4: System Selection Is Like Marriage

- ◆ Don't be taken by looks

No one ever told me I was pretty when I was a little girl. All little girls should be told they're pretty, even if they aren't.

— Marilyn Monroe

# Lesson 4: System Selection Is Like Marriage

- ◆ Don't be taken by looks
- ◆ Without a strong relationship, it will not go well

“Before marriage, a girl has to make love to a man to hold him.  
After marriage, she has to hold him to make love to him”  
— Marilyn Monroe

# Lesson 4: System Selection Is Like Marriage

- ◆ Don't be taken by looks
- ◆ Without a strong relationship, it will not go well
- ◆ Have a good pre-nuptial agreement

“And sometimes good things fall apart so better things can fall together.”  
— Marilyn Monroe

# Lesson 5: Plan to Share

- ◆ It is becoming expected
- ◆ Plan for possibility of widespread access & worksharing
- ◆ Consultation & Integration with other specialties (particularly in new payment models like ACOs)

Beneath the makeup and behind the smile, I'm just a girl that wants to rule the world.  
--Marilyn Monroe

# Lesson 5: Plan to Share

- ◆ Within Enterprise
- ◆ Between Enterprises
- ◆ With Patients
- ◆ With Government

The body is meant to be seen, not all covered up.  
--Marilyn Monroe

# Lesson 6: Plan Big

- ◆ Data sizes follow Moore's law

\*Erickson, 2001

- ◆ Service level expectations grow exponentially too
- ◆ Don't need to buy at start, but plan for (rapid) expansion

## Lesson 7: Set realistic expectations

- ◆ Digital imaging does not solve all problems
- ◆ It will probably create several
- ◆ Work incrementally and actively engage the users and customers to catch problems early

No one ever called me pretty when I was a little girl.

--Marilyn Monroe

## Lesson 8: Leverage Industry Standards

- ◆ Vendors using industry standards usually win over the long term
- ◆ Push for broader standards (e.g. non medical like web services) Medicine is arrogant, and when you only have a hammer...

To put it bluntly, I seem to have a whole superstructure with no foundation. But I'm working on the foundation

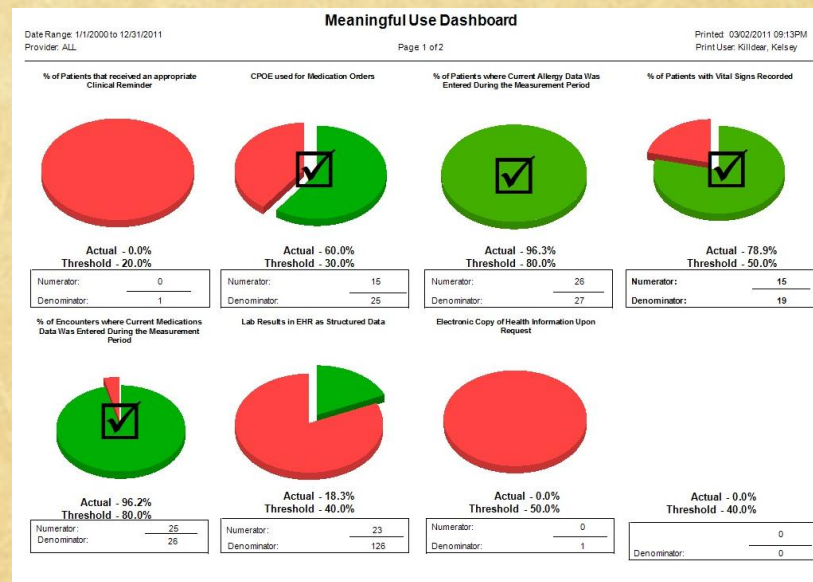
--Marilyn Monroe

# Lesson 8: Leverage Industry Standards



# Lesson 9: Integrate quality & performance

- ◆ Dashboards—enable your employees



“Give a girl a pair of great shoes and she can rule the world.”  
 — Marilyn Monroe

# Lesson 10: Select 'Nimble' Methodologies

- ◆ Technology is rapidly changing
- ◆ Don't build 'The Perfect Solution' and plate it in gold

Imperfection is beauty, madness is genius and it's better to be absolutely ridiculous than absolutely boring."

— Marilyn Monroe

# The Yin & Yang

- ◆ Must have actively engaged leadership to know when to follow standards versus nimbleness
  - ◆ Consultants are just that
  - ◆ You must own the decision
  - ◆ You can't "set it and forget it"

"They've said I want to direct pictures. I couldn't direct traffic."  
— Marilyn Monroe

# Conclusions

- ◆ Don't assume everyone knows your business
  - ◆ Workflow
  - ◆ Customers
  - ◆ Terminology

“We should all start to **live** use *digital imaging* before we get too old. Fear is stupid. So are regrets.”

— Marilyn Monroe

# Conclusions

- ◆ Select the system like you *should* select a spouse
  - ◆ Don't be taken by appearances
  - ◆ Pick a vendor you have or can build a strong relationship with
  - ◆ Good pre-nuptial
  
- ◆ Hope for the best, Plan for the worst

“We should all start to *live use digital imaging* before we get too old. Fear is stupid. So are regrets.”

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# Conclusions

- ◆ Expect Change
  - ◆ Leverage standards where you can
  - ◆ Nimble technology where you can't

“We should all start to **live** use *digital imaging* before we get too old. Fear is stupid. So are regrets.”

— Marilyn Monroe

# Thank You!

- ◆ “A wise girl kisses but doesn't love, listens but doesn't believe, and leaves before she is left.”  
— Marilyn Monroe