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Software Bugs or Features - Troubleshooting the Black Box: Part 1

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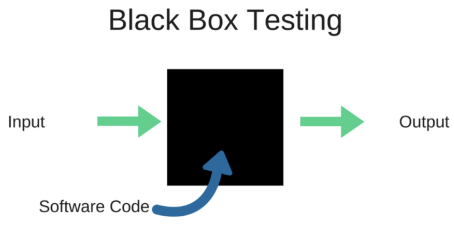
Introduction – Projectional X-ray

- Radiology acquisition systems (X-ray, CT, MR, US): software is a key component
  - User interface
  - Hardware controllers, drivers
- Unexpected output
  - Troubleshooting steps to narrow the root cause
  - Work with vendors to understand the inner workings



Troubleshooting to Solution

- Development of workarounds
  - Dependent on the scenario
  - Actual clinical impact on patient care
  - Vendor limitations

Case #1: General Radiography Exposure Index

- New Digital Radiographic unit (2016)
- Acceptance testing (regulatory - Pass)
- Exposure Index (EI) validation
  - 5% (within spec)
  - acceptable limit +/- 20% per IEC and vendor

IEC 62494-1
AAPM TG 116
AAPM TG 232

EI = 100 (detector μGy)

Case #1: General Radiography Exposure Index

- Deviation Index (DI)
  - EI_T = Target (aim) EI for the projection
  - EI << EI_T (noise), EI >> EI_T (pt. dose)
  - If EI = EI_T then DI = 0 (on target)
    - 10 log (1) = 0
  - DI >> 0 (possibly overexposed)
  - DI << 0 (possibly underexposed)

$$DI = 10 \log (EI/EI_T)$$

AAPM TG 232
DI usable ranges
Accounts for equipment and technologist variability

Case #1: General Radiography Exposure Index

- EI target set at 252 (Abdomen)

Anatomy	Patient Size	Factory Target EI
Abdomen		
antero posterior	Pediatric	252
antero posterior	Adult	252

EI_T

Case #1: General Radiography Exposure Index

- DI validation: AEC
  - AEC Speed: 125
  - EI = 852
- EI_T = 252 (default in setup screen)
- Expected DI value = 5.3
  - DI = 10 log (852/252)
- Displayed DI value = 0.2

EI = 100 (detector μGy)
DI = 10 log (EI/EI_T)

Potential Problem

- If the technologist used DI as a feedback mechanism:
  - Patients could be routinely overexposed
  - DI indicating 'in range' but patient would have received 3x dose
- EI target was not displayed on the acquisition display
  - Could not see EI target settings without superuser permissions

Troubleshooting

- Rechecking EI setups & values
  - EI accuracy
  - EI linearity
  - EI with AEC checked out
- DI still had unexpected results

Troubleshooting

- DICOM information
  - EI_T = 806

Anatomy	Patient Size	Factory Target EI
Abdomen		
antero posterior	Pediatric	252
antero posterior	Adult	252

EI	(0018, 1411)	851.935
EI_T	(0018, 1412)	806.4
DI	(0018, 1413)	0.2

Target EI changing behind the scenes

Troubleshooting

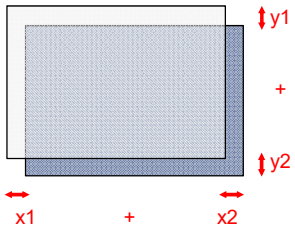
- Changing factors – speed
- Escalation with the vendor (weeks)
  - White paper that described the relationship between AEC speed, the programmed user/default EI_T and the final EI_T
- Bug or feature?
- Workaround
  - Techs instructed not to use DI as a guide, only rely on the EI

Additional thoughts on this case study:

- Speed terms (100,400..) are legacy term (analog) can probably be eliminated from use
  - AEC systems tied to EI targets
  - Straightforward configuration (engineer and technologist)
- Target EI values should be displayed as a guide

Case Study #2 – Mammography Collimation

- New installation: Digital tomosynthesis mammography unit
- Updated model
- Collimation test (light field to x-ray field)
  - 2% SID tolerance (follows radiographic standards)
  - Self developing (Gafchromic) film
  - Failed the test in tomosynthesis mode

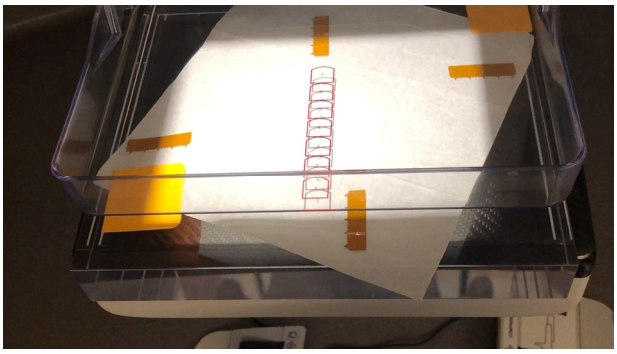


FYI: Possible SAM Erratum

- one 'dimension' – not one 'direction'

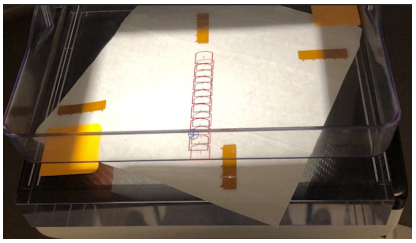
X-ray to light field – Tomo

- Centered Gafchromic strips with light field
- During acquisition, collimators opened
- After acquisition, the collimators close
- No user interaction

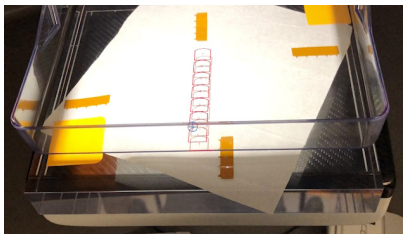


Tomosynthesis mode:

- Compliance failed
  - X-ray extends beyond planned area @ left, right, anterior



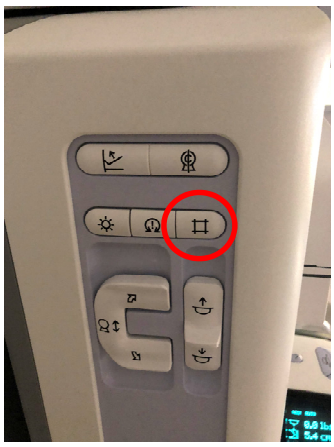
Prescribed field



Delivered field

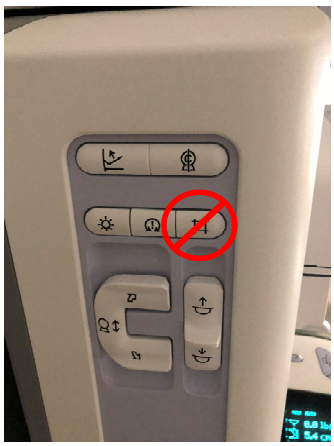
Software issue

- Programming of collimation button
- Prior models had deactivated this button (tomo)
- New version was not disabled - allowed beam restriction in tomo
  - When the field size was set smaller - the beam opened up anyway



Troubleshooting

- Escalated through the vendor
  - Showed difference in operation on systems
  - Acknowledged the 'bug' & issued a patch
- Workaround
  - Advised techs to not to push the collimation button during tomo exposures
  - Same patient dose compared to normal operation (less clinical impact)



Additional notes

- Tracking down software issues can be time consuming
- No guidebook
  - Professional experience of clinical impact
- Vendor moderated user groups
- Bug reporting systems

Next: Part 2