Use of Agile & Lean methods to develop X-Ray Analytics Application.

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Presentation Outline:

1. Product Introduction: X-ray Quality Application / Repeat-Reject Analytics (RRA)

2. Team structure & Tools

3. Scoping for beta (1st MVP*) & development/release cycle.

4. Beta deployment & Insights Learned

5. From beta insights to 1st product release.

6. Summary & Conclusion.

Product Description: X-Ray Quality App. / RRA

Digital X-ray Imaging Workflow (Simplified):

1) HIS/RIS:
Patient registered
Imaging order placed

Hospital Information System /
Radiology Information System

2) Modality:
Images acquired /
Inspected

3) PACS:
Images reviewed /
Diagnostic

Position Patient /
Anatomy of interest

Acquire X-ray Image

Image Accepted*?

Yes

Exam Complete

No: *Repeat Acquisition*
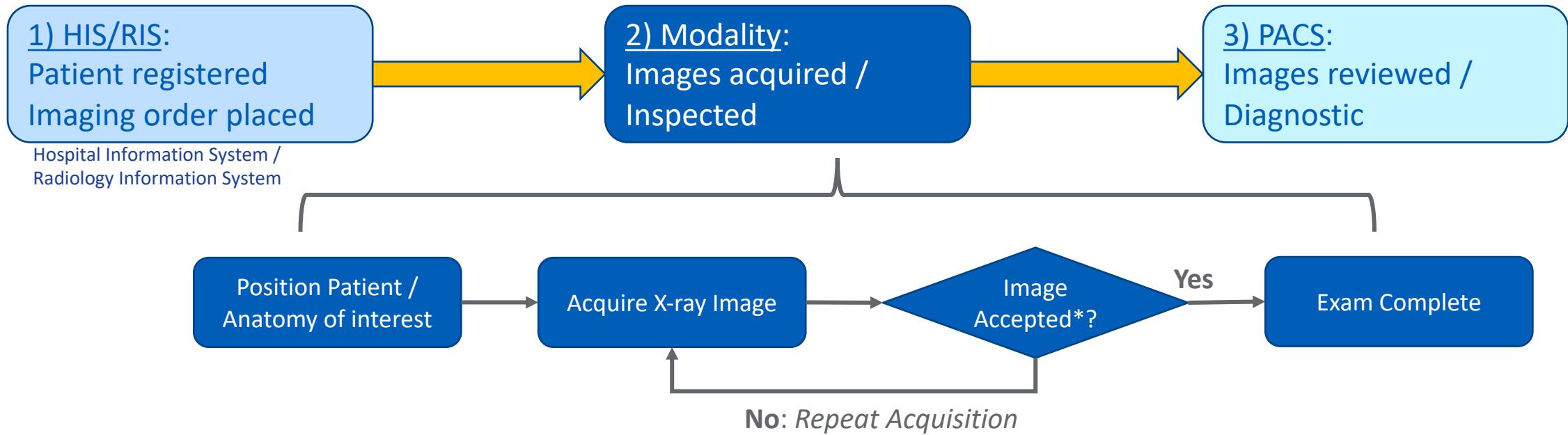
* Notes:
- *Rejected (non-accepted) images are not sent to PACS (no diagnostic value)*
- *The technologist might avoid a repeat by "re-processing" the image using a different set of processing parameters.*

Product Description: X-Ray Quality App. / RRA

Clinical Problem Statement:

Rejected X-ray images represent:
1. Un-necessary radiation exposure to patients (Re-take).
2. Wasted time and resources, and
3. Risk of non-compliance

ASRT (American Society of Radiologic Technologists) Position:
It is a best practice in digital radiography to implement a comprehensive quality assurance program that involves aspects of quality control and continuous quality improvement, including repeat analyses that are specific to the digital imaging system.

AAPM: The American Association of Physicists in Medicine:
Adults: "this task group recommends that 8% be used as a target for overall rejected image rate, and 10% as a threshold for investigation and possible corrective action."

X-ray quality App. RRA Position Statement :

For (end-users):	Users of X-ray medical imaging equipments (Lead Tech, QA, Manager, Physicist)
Who (users' needs):	Want to measure and track Repeat-Reject Rate and identify corrective actions to keep it under a target of X %
Product name:	Repeat-Reject Analytics
Product Features:	1. Facilitates the collection of RRA data from various X-ray imaging equipments 2. Aggregates the collected data across multiple equipments / vendors 3. Extract data elements that are relevant to Repeat-Reject operations 5. Displays the data on user-friendly and user-adjustable dashboards.

Note: RRA was determined not to be a medical device and hence not subject to QSR on Design Controls.

Product Architecture:

X-ray Devices

XR220

XR240

XR656/Plus

XR646

Ingestion Server

X-ray Ingestion Service

- Register/Configure GE Devices
- Secured network-based data import
- Extract & organize imported data
- Upload HIS/RIS Export for Operator Name
- View history & status

Web Applications

Admin/Registration +
Upload Tool

Analytics Server

GE Applied Intelligence Platform

- View top insights
- Drill down into specific details
- Review jpegs of rejected images
- Export a report for QA program

Dashboards

2) Team Structure & Tools:

Global development team:
1. Product Manager
2. Lead Systems Designer / Architect
3. Lead SW Designer / Architect
4. SW team (3 engineers)

Requirements Management: DOORs for user and system requirements

Verification & Validation: DOORs for authoring procedures & traceability to design input.

Agile development & issues tracking: Rally

3) Scoping for 1st Minimum Viable Product (MVP):

Developed a set of user and system level requirements to drive design and development activities:

User Requirements:

1. Access controls & users management.
2. X-ray Devices Registration: GE only
3. Analytics Dashboard: Visualization & Insights

System Requirements:

Elicitation and translation of user requirements to product requirements.

SW requirements:

System requirements were further decomposed into Rally.

RRA Beta development & release cycle

Prod. Development → SW release → Shared Repository → SW release → System Integration & Testing

XR220, XR240, XR656/Plus

Issues, Assessment, & Prioritization
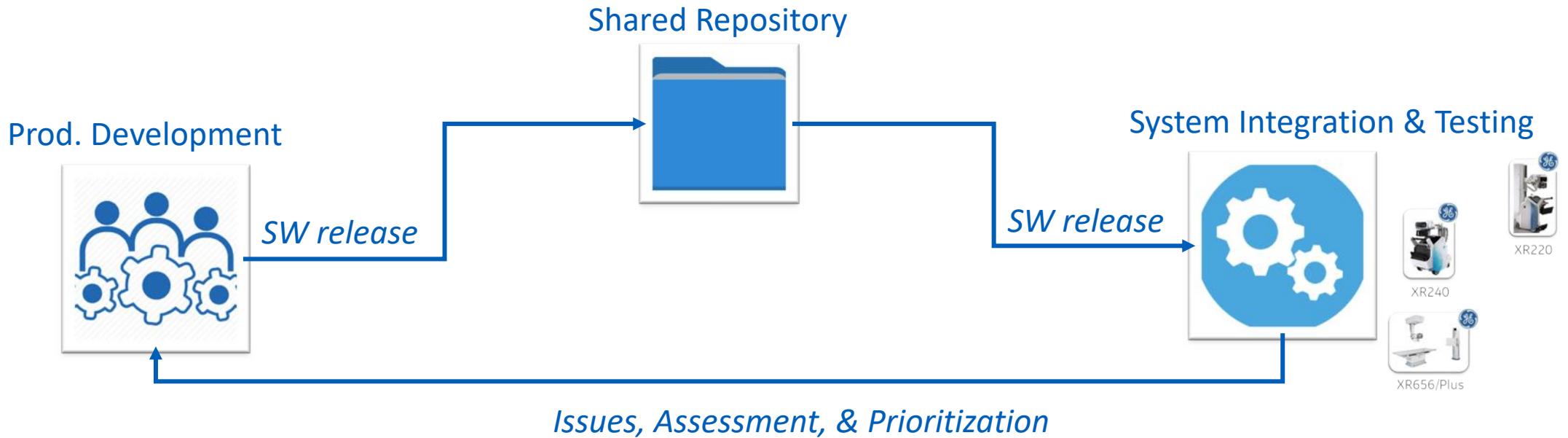
Main Highlights:

1. SW release frequency: Daily / every other day
2. Emails to share test outcomes & issues observed
3. Leveraged global structure: Integration testing (daytime) / SW development & issues resolution (nighttime) and so on…
4. ~10 SW releases in the 2 weeks period leading to beta

4) Beta Deployment: Radiology department at a US academic institution

Participants:

GE: Product manager, Lead system designer, Lead SW designer, Platform service lead.
Clinical Site: Lead X-ray technologist, IT staff members

1. Deployment of SW modules:
   a. Ingestion: No issues
   b. Dashboard: No issues
2. Registration of X-ray devices:
   a. Fixed X-ray systems (wired): Firewalls configuration update required* (inside Radiology network).
   b. Mobile X-ray systems (wireless): Unsuccessful** during deployment (fixed later)

* A firewall exception is needed to allow the ingestion server to connect to fixed X-ray systems. Radiology IT created the exception during deployment.
** A similar exception was needed for the wireless network. However, that network was managed at the enterprise level thus requiring a more complex workflow & different approvers. Upon completion of workflow, Mobile devices were successfully registered & their data ingested.

Beta 1st Deployment: Cont'd

- ✓ Per agreement with site staff, we limited the scope of deployment to fixed X-ray (wired) devices pending completion of wireless configuration change.
- ✓ No change in functional scope for Ingestion & Dashboard Modules.
- ✓ Beta up and running: Data ingested from devices and displayed in dashboards.
- ✓ Established a mechanism to collect customer feedback and comments.

<u>1st immediate insight</u>: Check network configuration and ownership as "deployment prerequisite".

Beta deployment, 2nd insight: Operator Name Prioritization

The beta SW used a pre-defined prioritization schema such that each X-ray imaging exam is assigned ONE operator name. The operator name can originate from:

1. X-ray acquisition system: Technologist enters her/his name at the start of an exam.
2. HIS/RIS*: Technologist enters her/his name at exam closure time on the HIS/RIS.
3. Reject Operator (*for rejected images only*): Technologist enters her/his name at the time of image rejection (UI of the X-ray acquisition system).

However, we learned that different sites can have different "preferences" about how to prioritize assignment of operator name to imaging exams.

Without a configurable prioritization schema, the application can't account for observed workflow variations and preferences.

Beta deployment, 3rd insight: Operator Name Standardization

With operator names coming from three district sources, we observed variations in operator names based on where they come from.
For example, John Doe can be:
1. John D. coming from the X-ray acquisition system.
2. Doe, John coming from HIS/RIS.
3. J. Doe coming from the reject UI (*for rejected images only*)

Without standardization (consolidation), the three varied forms will show as three different operators on the dashboards.

Beta deployment, 4ᵗʰ insight: Need more "specialized" dashboards

The beta SW provided a single dashboard for all registered devices, all technologists, for all reject classifications.

Customer insight: This is OK but can you provide:
- <u>Technologists dashboard</u>: Where the lead tech can display and filter reject data on a per technologist basis.
- <u>Reprocess reject dashboard</u>: Where the lead tech can display and filter reject data based on "reject classification" to account for the imaging workflow where a rejected X-ray image can be classified as:
  - Repeat: Indicating a X-ray retake by the technologist
  - Re-Process: Indicating that the rejected image was obtained by an image re-processing operation and hence no need to perform a re-take.

5) From beta to 1ˢᵗ product release: Configurable Op. Name Prioritization

Designed & implemented a UI feature that allows lead X-ray technologists to configure the prioritization schema based on their site's workflow:

Site A

Technologist Name Priority

Priority #1	Reject Technologist Name from Acquisition System ▾
Priority #2	Technologist Name from HIS/RIS ▾
Priority #3	Exam Technologist Name from Acquisition System ▾

Save Changes

Site B

Technologist Name Priority

Priority #1	Technologist Name from HIS/RIS ▾
Priority #2	Reject Technologist Name from Acquisition System ▾
Priority #3	Exam Technologist Name from Acquisition System ▾

Save Changes

From beta to 1st product release: Op. Name Standardization

Designed & implemented a UI feature that allows lead X-ray technologists to consolidate "variations" of technologists names (alternates) into a single standard operator name.

# From beta to 1st product release: Additional dashboards

Designed & implemented a per-technologist & a reprocess reject dashboard to address customers requests.

Technologist Dashboard:
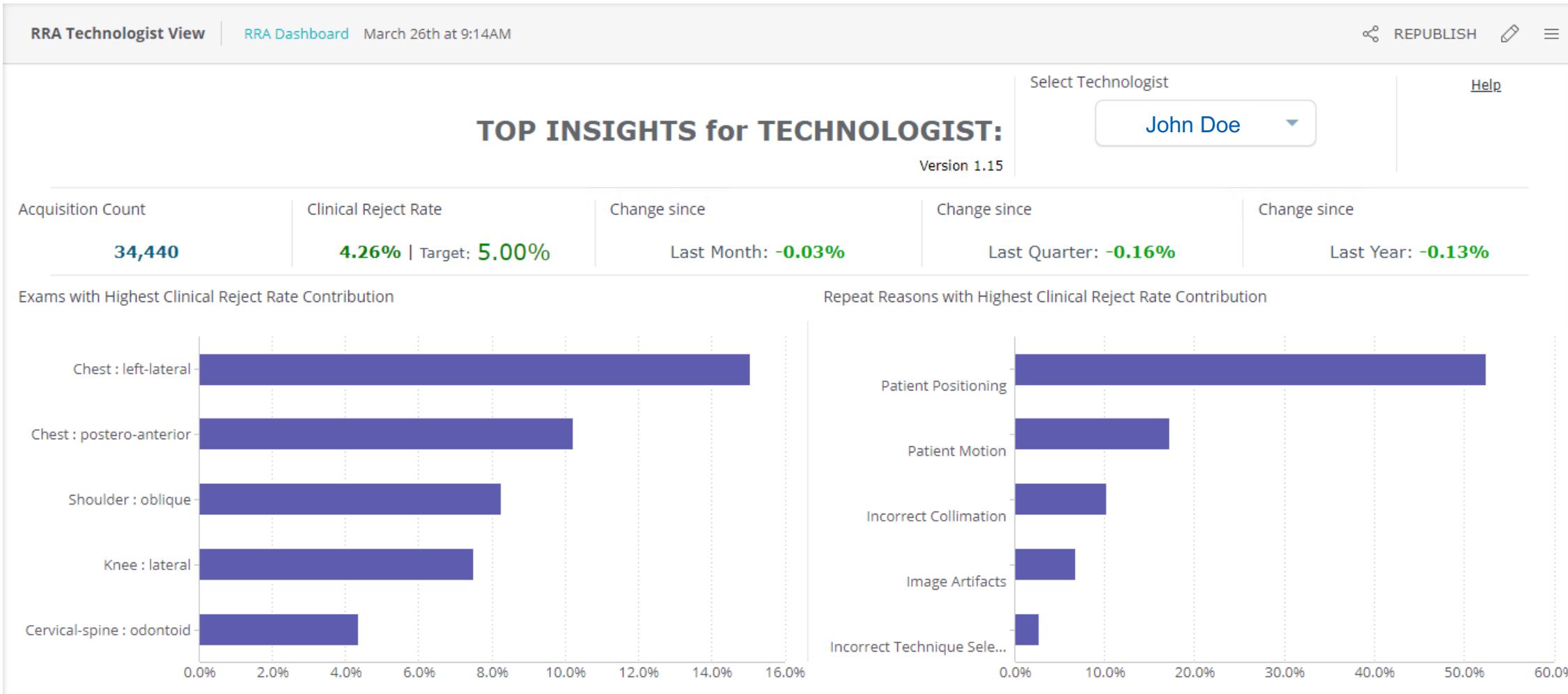
From beta to 1ˢᵗ product release: Additional dashboards – Cont'd

Reprocess Reject Dashboard:
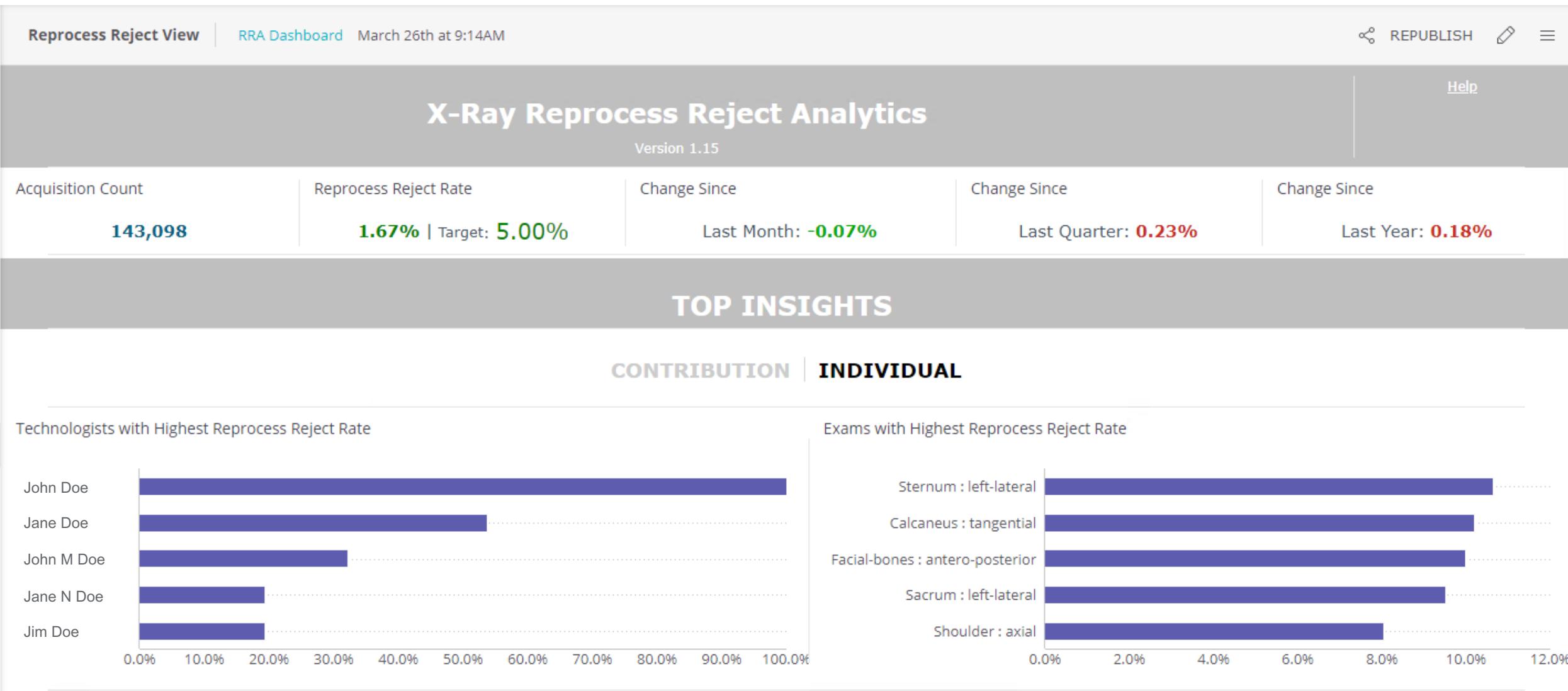
6) Summary & Conclusion:

- Real life product development experience using agile & fast-works.

- Lean processes for design & development: requirements, integration testing, defects tracking

- Beta deployment experience & clinical insights learned: Get an MVP (Minimum Viable Product) in customer hands ASAP, the ROI is extremely valuable.

- From beta to 1st product release: transformation of customer insights -> product features to address end-user needs and pain points.