Machine Log Data Mining

INTEGRATING ANECDOTAL MACHINE LOG DATA INTO THE TOTAL QA PICTURE.

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image OWL | TOTAL QA

Overview

The Total QA System

Context

Machine Log Background and Experience

Integrating Machine Log Data with QA Measurement Data

Making Use of the Data

Control Charts
Word Clouds
Sentiment Analysis
Natural Language Processing (NLP)
??

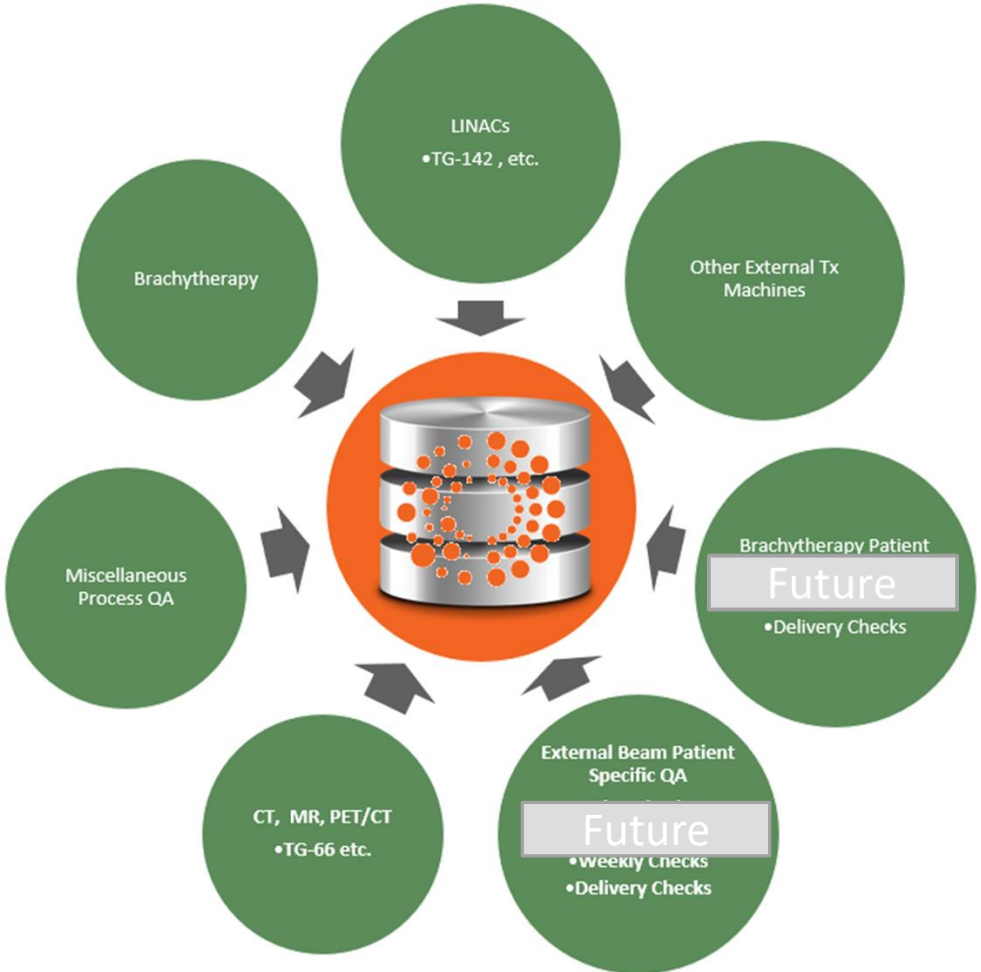
TOTAL QA

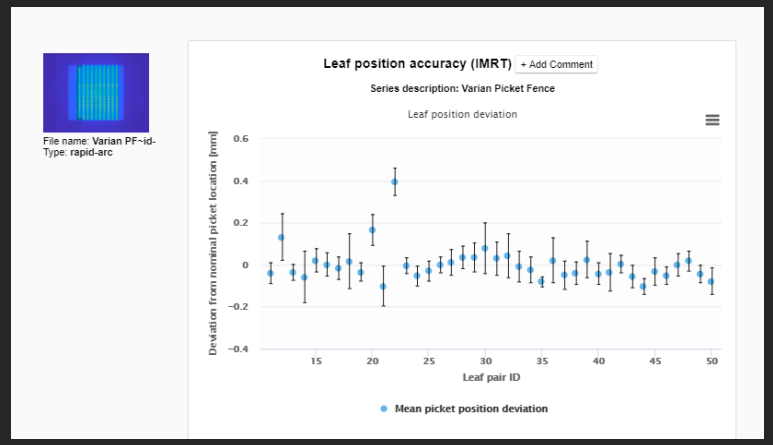
A powerful, cloud-based and vendor-neutral QA data management system.

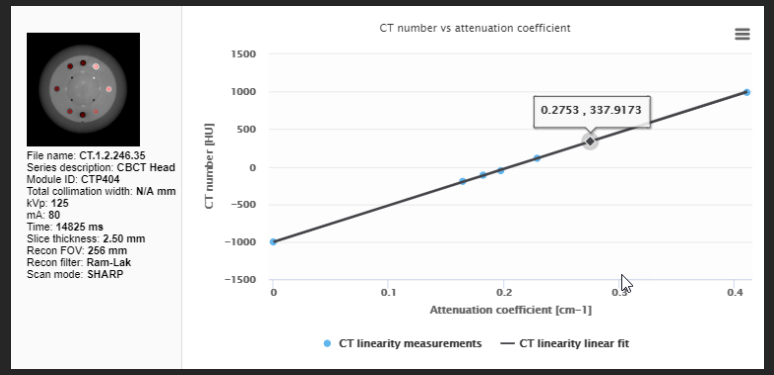
Total QA addresses the “Data Silo” problem

Our clients start with a mix of isolated QA devices, checklists, forms, image processing software, and spreadsheets.

When trying to integrate their QA, they are frustrated by systems that won’t talk to each other or adapt to their needs.

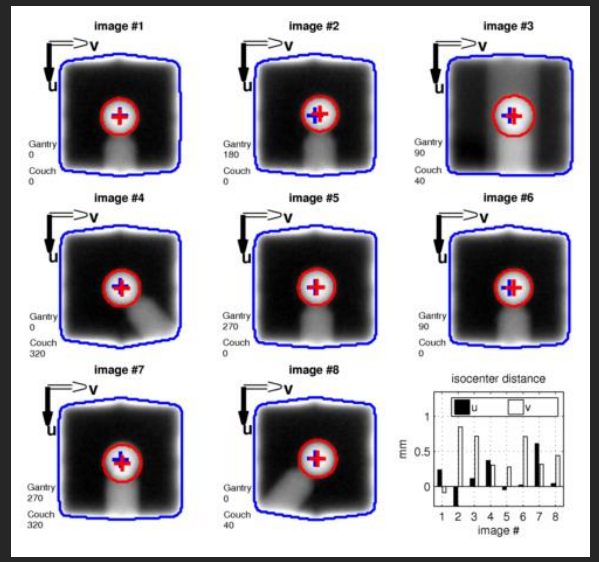


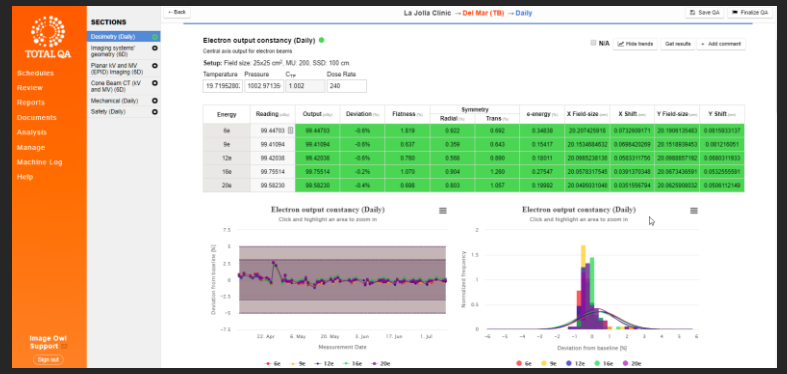




Total QA Integration

- Daily QA Devices
- Phantom Analysis
- Dosimetry Measurements
- Checklists
- Beam Profiles
- MLC Tests
- Varian MPC Data
- .....





Another Data Silo

Medical Physics QA Measurements Vs. Machine Incident Logs and Service Reports

Both are different views of the same equipment.

If we want to have a complete picture of our equipment shouldn't we integrate these data sources?

When investigating measurement anomalies wouldn't it be useful to be able to see reported incidents and associated materials at the same time and leading up to the anomaly?

Flipping this, when investigating an incident wouldn't it be often useful to look at what the related measurements were doing before and after resolution?

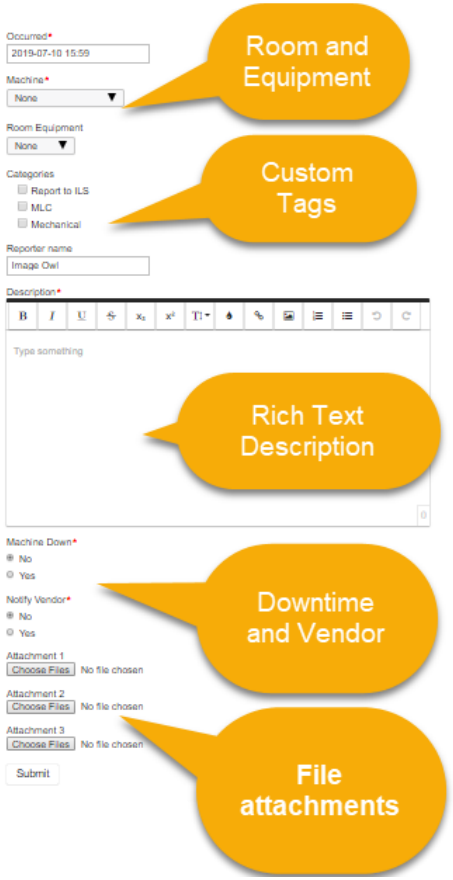
Wouldn't it be useful to see similar incidents and how they were handled previously?

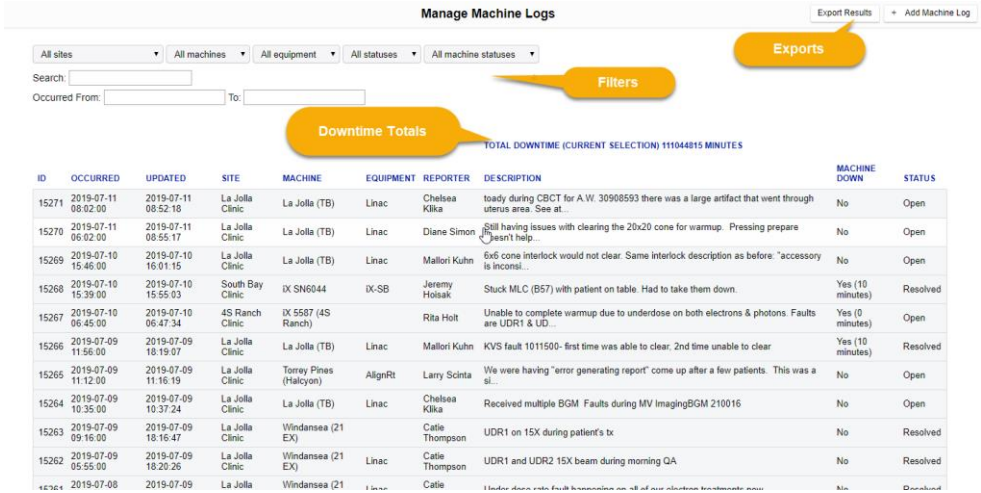
Logging Machine Incidents

Our Machine Log system originated at UC San Diego where they developed an in-house system.

At the end of 2018 we integrated it into the Total QA system.

Machine Log allows users to record issues, downtime, and track resolution of machine and equipment incidents.





ID	OCCURRED	UPDATED	SITE	MACHINE	EQUIPMENT	REPORTER	DESCRIPTION	MACHINE DOWN	STATUS
15271	2019-07-11 08:02:00	2019-07-11 08:52:18	La Jolla Clinic	La Jolla (TB)	Linac	Chelsea Klika	toady during CBCT for A.W. 30908593 there was a large artifact that went through uterus area. See at...	No	Open
15270	2019-07-11 06:02:00	2019-07-11 08:55:17	La Jolla Clinic	La Jolla (TB)	Linac	Diane Simon	Still having issues with clearing the 20x20 cone for warmup. Pressing prepare doesn't help...	No	Open
15269	2019-07-10 15:46:00	2019-07-10 16:01:15	La Jolla Clinic	La Jolla (TB)	Linac	Mallori Kuhn	6x6 cone interlock would not clear. Same interlock description as before: "accessory is inconsi...	No	Open
15268	2019-07-10 15:39:00	2019-07-10 15:55:03	South Bay Clinic	iX SN6044	iX-SB	Jeremy Hoisak	Stuck MLC (B57) with patient on table. Had to take them down.	Yes (10 minutes)	Resolved
15267	2019-07-10 06:45:00	2019-07-10 06:47:34	4S Ranch Clinic	iX 5587 (4S Ranch)		Rita Holt	Unable to complete warmup due to underdose on both electrons & photons. Faults are UDR1 & UD...	Yes (0 minutes)	Open
15266	2019-07-09 11:56:00	2019-07-09 18:19:07	La Jolla Clinic	La Jolla (TB)	Linac	Mallori Kuhn	KVS fault 1011500- first time was able to clear, 2nd time unable to clear	Yes (10 minutes)	Resolved
15265	2019-07-09 11:12:00	2019-07-09 11:16:19	La Jolla Clinic	Torrey Pines (Halcyon)	AlignRt	Larry Scinta	We were having "error generating report" come up after a few patients. This was a si...	No	Open
15264	2019-07-09 10:35:00	2019-07-09 10:37:24	La Jolla Clinic	La Jolla (TB)	Linac	Chelsea Klika	Received multiple BGM. Faults during MV ImagingBGM 210016	No	Open
15263	2019-07-09 09:16:00	2019-07-09 18:16:47	La Jolla Clinic	Windansea (21 EX)		Catie Thompson	UDR1 on 15X during patient's tx	No	Resolved
15262	2019-07-09 05:55:00	2019-07-09 18:20:26	La Jolla Clinic	Windansea (21 EX)	Linac	Catie Thompson	UDR1 and UDR2 15X beam during morning QA	No	Resolved
15261	2019-07-08	2019-07-09	La Jolla	Windansea (21	Linac	Catie	Under dose rate fault happening on all of our electron treatments now	No	Resolved

Machine Log Automated Vendor Contacts

Machine Log can be configured to automatically notify vendors under specific conditions.

Selected personnel within the clinic will receive notifications on updates.

A new Machine Log incident (15052) has been created:

Click here to view/edit in Total QA

Demographics

Customer Site:	y Clinic
Customer Number:	6057394

Event

Occurred:	2019-05-16 18:09:00
Machine Room:	iX SN6
Room Equipment:	iX-SB
Serial Number:	6044
Reporter Contact:	
Contact Phone Number:	
Contact Email:	
Report ID Number:	15052
Description of Event:	OBI making loud noise during and after imaging. Local tech was notified last week, now nois
Machine Down:	No
Vendor Contacted:	No
Downtime (minutes):	0

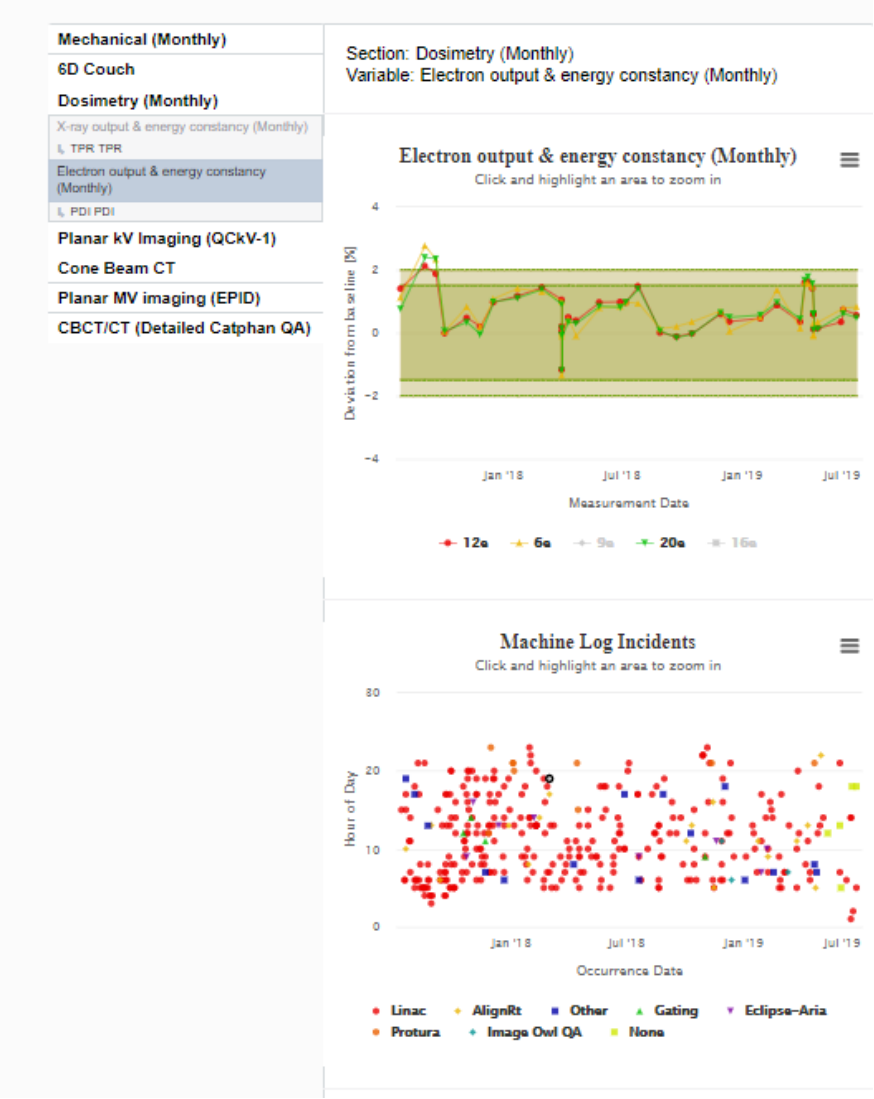
Vendor

Vendor:	Varian SB
Vendor Contact Name:	Support
Vendor Email:	support@varian.com
Vendor Phone:	888-827-4265

Comparison of Machine Log and Measured Data

Examine machine log incidents over the same period as longitudinal plots.

Click on incidents to see details.



Real Results with Machine Log

82%

Decrease in time to service response (45 to 8 minutes)

68%

Decrease in treatment cancellations or reschedules

47%

Total decrease in weekly downtime

Operational Improvements from Machine Log Implementation

Improving linear accelerator service response with a real-time electronic event reporting system (Jeremy D. P. Hoisak et al, September 2014, JACMP

Getting More Out of the Data

The first group of facilities to use this system have accumulated over 5800 individual incidents.

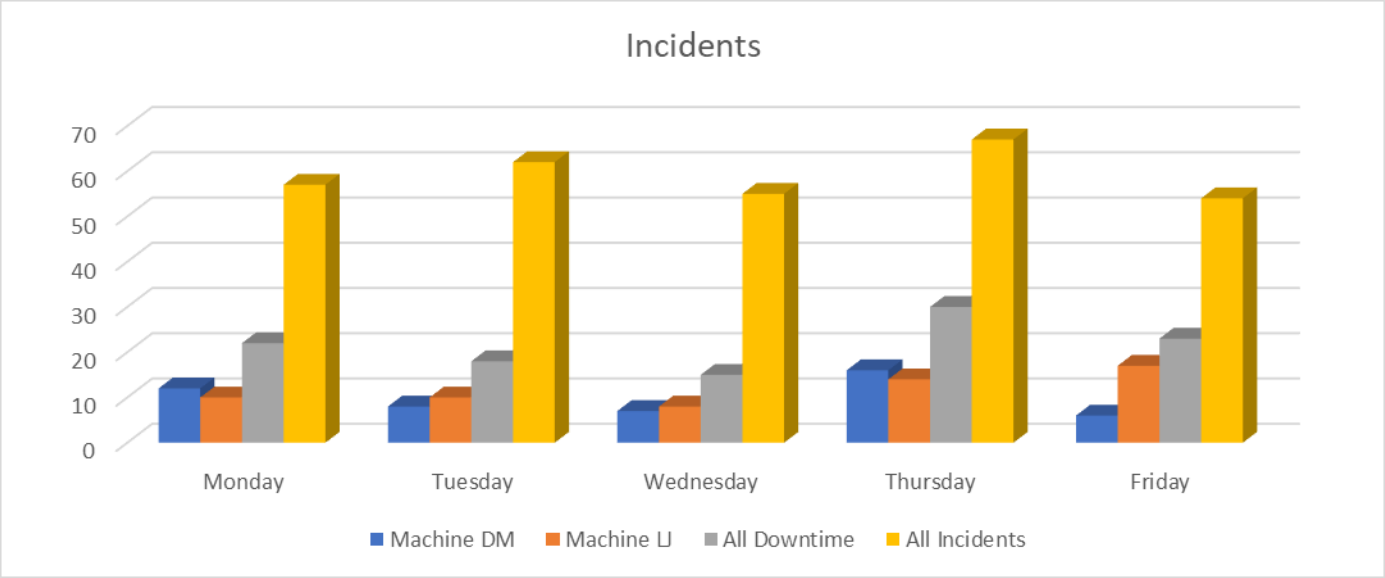
How can we mine this trove of data for operational and clinical insights?

Exploratory Analysis

Having the data in the database allows us to find potentially interesting questions to ask.

E.g. Do downtime incidents happen more frequently on certain days

	Downtime Incidents			
	Machine DM	Machine LJ	All Downtime	All Incidents
Monday	12	10	22	57
Tuesday	8	10	18	62
Wednesday	7	8	15	55
Thursday	16	14	30	67
Friday	6	17	23	54



Statistical Process Control (SPC)

Example Question: If a Linac has an unusual number of incidents reported on a single day is that associated with an increased occurrence of a downtime incident in the next several days.

To get there we have to answer a couple of questions:

1. What constitutes an unusual number of incidents?
2. What is the mean time between any given day and the next downtime incident (or half the mean time between downtime incidents)?

What is the cumulative probability for any given day that a downtime incident will occur within 1,2,3… days?

Then compare this to days with unusual amounts of activity.

SPC (Answering the questions)

Examined the machine log incidents reported on a single Linac over the period of a year.

Excluded weekends. There were some incidents reported on weekends, but they were rare.

For count data like the number of incidents one possible SPC chart to use is called a c-chart.

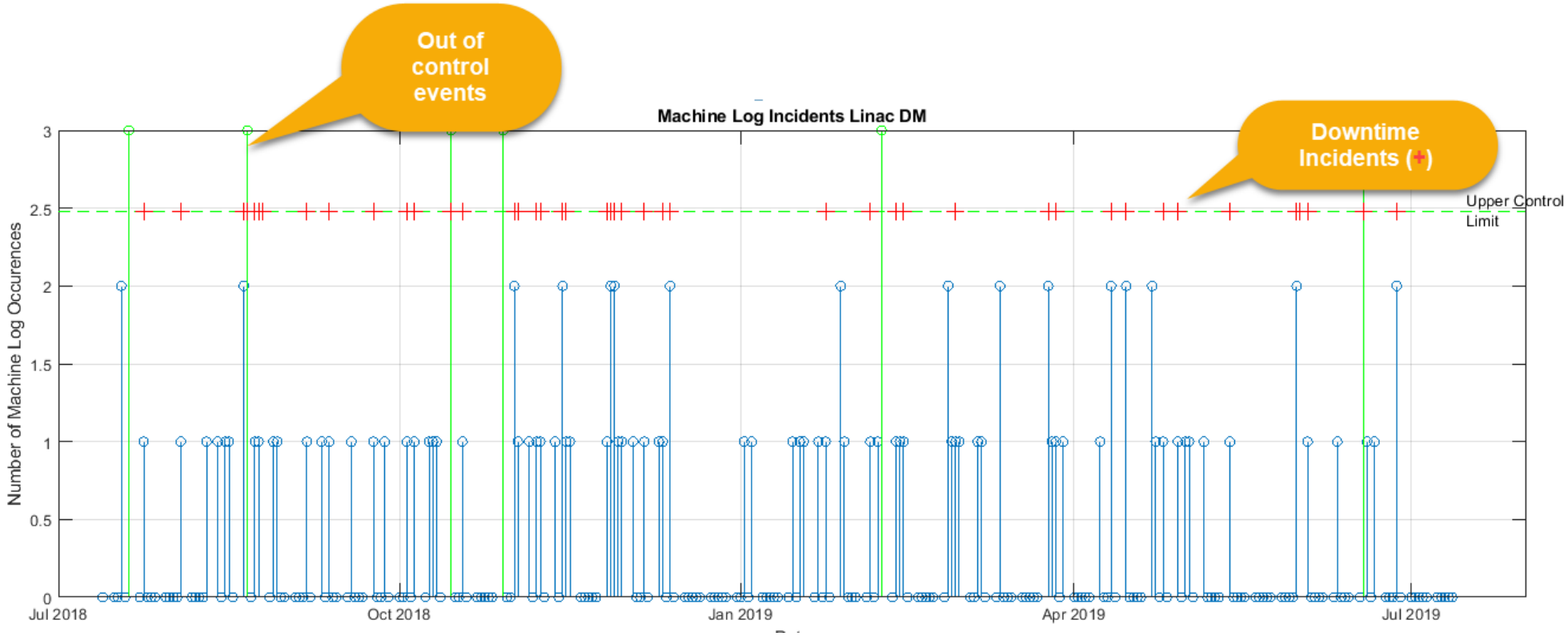
What constitutes an unusual number of incidents?

The Upper Control Limit for a c-chart is $\bar{c} + 3\sqrt{\bar{c}}$ where $\bar{c}$ is the mean count.

For this particular Linac it had a mean number of incidents of 0.46 per day and so the upper limit becomes 2.48. So <u>3 or more incidents in a day is considered unusual</u> and worthy of extra investigation.

The average number of days until the next downtime incident was 5.0 days

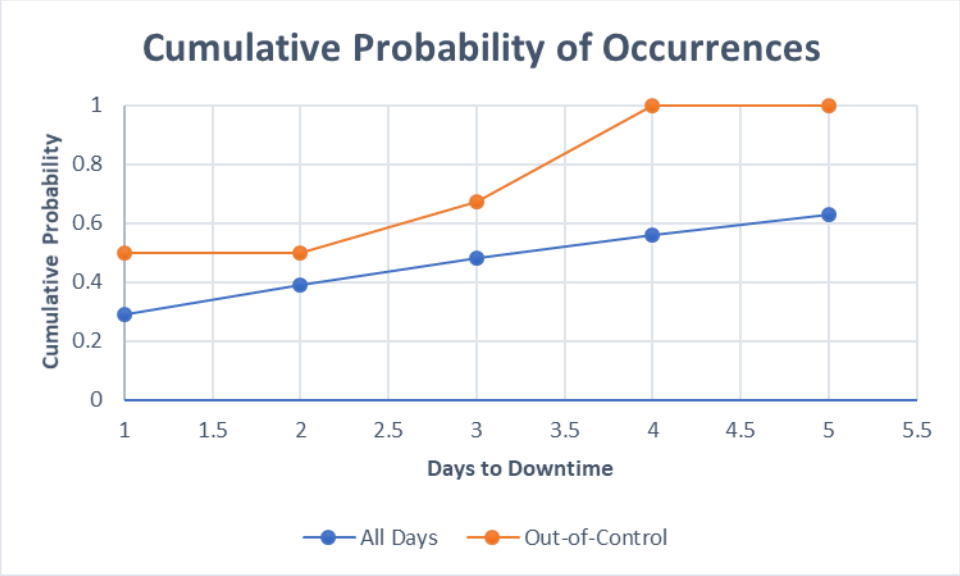
SPC Chart of Reported Incidents



Associations

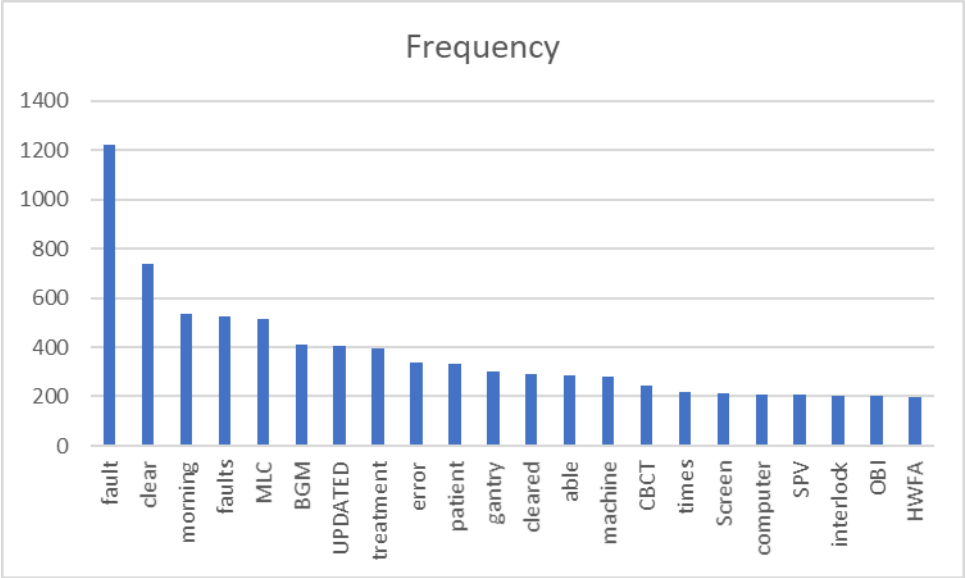
Days to Next Downtime Occurrence	
Mean for all days in year	Mean for Out-of-Control Points
5.0	1.8

Cumulative Probability of Occurrences		
Days to Down Time	All Days	Out-of-Control
1	0.29	0.50
2	0.39	0.50
3	0.48	0.67
4	0.56	1.00
5	0.63	1.00



Word Clouds

Word	Frequency
fault	1221
clear	737
morning	534
faults	526
MLC	513
BGM	409
UPDATED	406
treatment	394
error	338
patient	332
gantry	300
cleared	290
able	286
machine	281
CBCT	246
times	220
Screen	215
computer	207
SPV	206
interlock	203
OBI	202
HWFA	199



Sentiment Analysis

Sentiment analysis is contextual mining of text which identifies and extracts subjective information in source material and helping a business to understand the social sentiment of their brand, product or service while monitoring online conversations.

https://towardsdatascience.com/sentiment-analysis-concept-analysis-and-applications-6c94d6f58c17

Why would want to do this?

The obvious answer is that if we are providing a service, we want to make sure that our customers are not getting frustrated.

While machine log entries by their nature are not likely to be very positive, we want to keep them closer to neutral than overtly negative.

Beyond the overt customer satisfaction monitoring it is possible that changes in sentiment may capture frustrations not fully expressed in the log and presage actual machine issue.

Some examples

Still having issues with clearing the 20x20 cone for warmup. Pressing prepare doesn't help...

Positive 13.90 %

Neutral 21.80 %

Negative 64.30 %

There is an artifact on our CBCT. We can see it on S.Z.

Positive 13.50 %

Neutral 38.40 %

Negative 48.10 %

MLC fault cleared..all is good

Positive 79.80 %

Neutral 12.30 %

Negative 7.90 %

https://www.paralleldots.com/sentiment-analysis

Conclusions

There is real potential at integrating automated analysis of anecdotal machine log data into other data streams such as MLC log files, QA measurements and other sources to monitor current system state and possibly to predict future events.

There are a wide variety of techniques that can be employed on natural language logs and it will take some further experimentation to determine which are most useful in the context of radiotherapy diagnostic imaging machine service .

Acknowledgements

I'd like to thank our collaborators at UC San Diego whose devotion and discipline to the machine log idea over the years has produced an extraordinary body of experience and data in this area.

Their continuing insightful feedback and suggestions have made the integration of the Machine Log into Total QA.

In particular:

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Dr. Grace Kim

Dr. Jeremy Hoisak

Dr. Ryan Manger

And many, many others.