Link to Jira: {ANALYSIS-243}

Executive Summary

Purpose

- We would want to quantify the effect on the reliability of the WMEC RB of the recent failures that require a human interaction with the RB on site. We would know, based out of this quantification, the level/need to have FTE presence on site to address these issues. As the RB operates more and more reliably, we would want to know what our site expectation presence should be.

Outputs/Conclusions

- The number of faults and type of faults that required FTE presence at WMEC during the last three months
- The probability of having one of those faults or events during a reasonable study period
- The dependency of us having FTE deployed to address these faults at WMEC. This will ultimately address the question: Can we have no site presence (level 3) deployment at WMEC so that we are still available to come up with decent savings at the end of the month?

Acceptance Criteria

- There is a quantification of faults, failures, and instances that forced FTE to physically take action on-site
- From these results conclude the level of deployment that is necessary during the cloudshot duration
    - Each one of the failures should be addressable under the designated level of deployment
- Analysis to be revised by NS, MB

Methodology

- Parse the logs of the RB operation and instances in which we had to go to site to physically interact with the RB
- Categorize the events that caused failures in such a way that they can be described, grouped, and referenced against each other

- Calculate the probability of each one of the failures for a specific time frame
    - We assume that each one of the failures is independent from each other
    - $P(failure\ of\ type\ x) = \frac{\#of\ failures\ of\ a\ type\ x}{Total\ \#\ of\ failures}$
- Calculate the expected number of failures over the next three months
    - $E[failures] = \sum_{i=1}^{n} P_i * \#failures_i$
- Assuming failure events are independent, calculate the probability of an RB failure that requires someone to go to site over the next three months
    - $P(RB\ failure) = 1 - \prod_{i=1}^{n}(1 - P_i)$
- Generate a probability function that describes the probability of K failures per billing cycle T (30 days=billing cycle)
    - $P(k\ events\ in\ interval\ t) = \frac{(rt)^k * e^{-rt}}{k!}$, $where\ \lambda\ is\ the\ average\ number\ of\ failures\ per\ interval$ $\lambda = rt,\ we\ are\ given\ a\ failure\ number\ r\ and\ a\ time\ t\ \ for\ the\ events\ to\ happen$
    - Assumptions:
        - *k* is the number of failures (events) that occurs in an interval of study and takes natural number values. That is, there are no 1.5 failures. Either it is a failure that makes us go to site or not.
        - Lambda, the rate of failure, is constant during the period of study that is, there are not active improvements that makes the rate of failure to go down during a specific period of study. Ideally we would be able to select different lambdas or rate of failure for specific periods of time. If there is a new period with new site improvements then the lambda will change and the system then is a new one with a new poisson process
        - The occurrence of one failure does not affect the probability of the second. For example, a failure in the FRM 7 does not affect the probability of a leak on the SI
        - Failure events do not occur exactly at the same time
- Generate insights based on acceptance criteria and the information collected

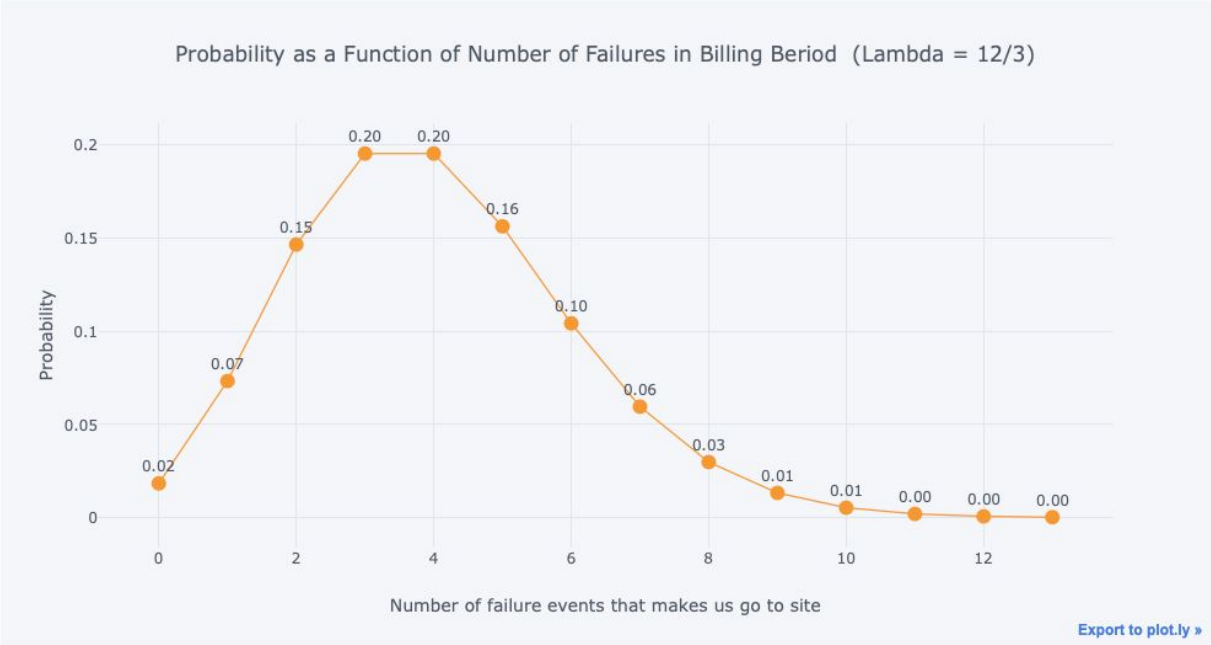
Results

- Events:
    - A = The FRM 7 fails making us go to site and get it manually unstuck
    - B = There is a leak on the RB
    - C = There is a sensor failure in the RB the hinders operation and has to be replaced (likely a component)
    - D = We have another event (that is not A, B, or C) that makes us go to site
- Log of events that cause FTE to go to site 7/2 - 9/24:

	July	August	September
A	0	4	0
B	0	1	1
C	1	1	0
D	1	2	1

- Probability of each one of the failures during a three month time frame
  - $P(A) = 4/12,\ P(B) = 2/12,\ P(C) = 2/12,\ P(D) = 4/12$
- $E[failures] = \sum_{i=1}^{n} P_i * \#failures_i = 3\ failures$
- Assuming failure events are independent, calculate the probability of an RB failure that requires someone to go to site over the next three months

  $P(RB\ failure\ during\ the\ next\ three\ months) = 1 - \prod_{i=1}^{n}(1 - P_i) = 0.69$
- The probability of having K failures in a billing cycle is represented as:



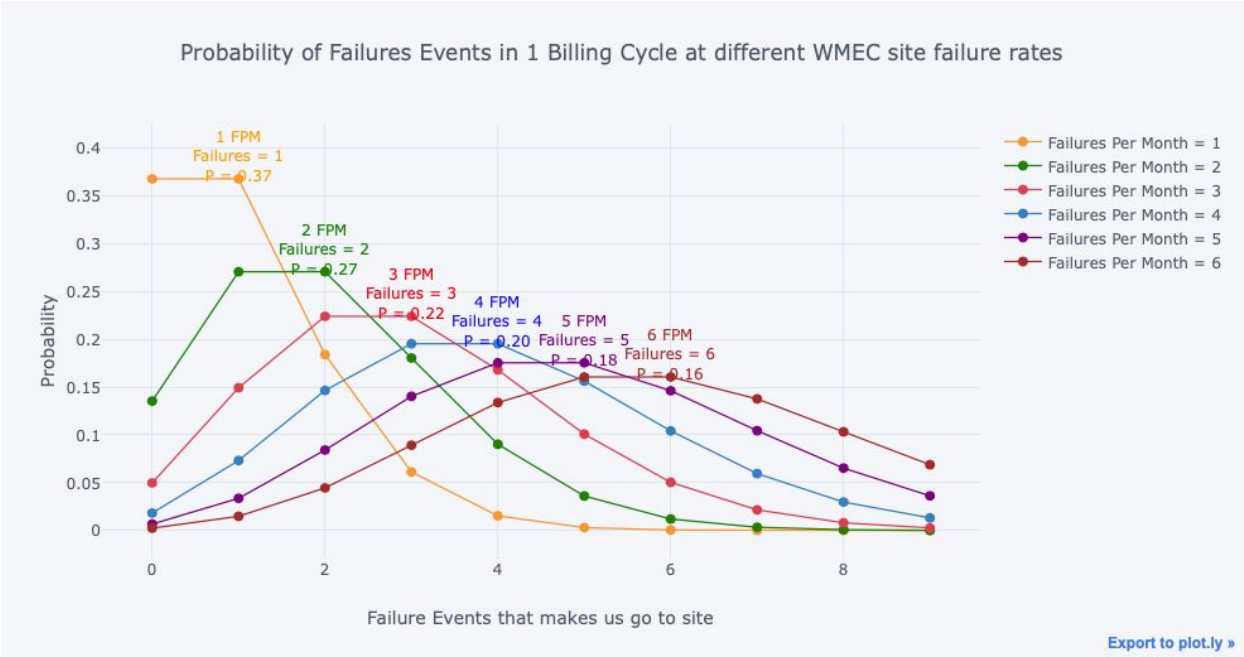
[Krunchy notebook]

A fixed lambda means a fixed state of the RB, that is there is no improvements in the system whatsoever and we therefore, have a constant failure rate over time. The Lambda value (12/3) was gathered from the last three months of operation. During those three months we made improvements:

- Fixed CRS receiver level issue

- Installed and tested remote power cycling capabilities
- Address LRP leaks and changed inlet flange o-ring
- Installed additional mission critical sensors

Since we have made improvements in the RB, we expect the failure rate per billing cycle - lambda- to go down.



Currently, based on the last three months worth of information, the WMEC site failures behave with probabilities similar to the RED line. That is, we have ~ 20% chance of having 3 failures per month. Since we have made improvements, and overtime, the failure events that makes us go to site at WMEC will likely behave similar to the YELLOW line. That is, we will more likely (~37%) have one single event that makes us go to site in a billing period. And per contrast, we would have a 6% chance to go to site there (3) times in a month or billing period.

To get to the YELLOW line, we would want:

- To continue to monitor site failure events and log them in a way that it can be useful for analysis
- Run the analysis every month to confirm/debunk the estimates
- Make improvements to site reliability as failures come as we have been doing during Saleshot and Cloudshot periods

Recommendation:

- *Staff the site on level two mode until (lambda) $\lambda = 1$, that is, one failure event that makes us go to site per billing period, and then move to level 3*
    - This is a safe bet
    - Level two means 30-40 mins response time to any event

- Level three means 8 hours at the most of response time to any event

With regards to each one of the events satisfying a response time of at least 8 hours:

A = The FMR 7 fails making us go to site and manually get it unstuck

In this case, if we have to go to site and get it unstuck, we would have to set the FRM in Co-Flow mode for the RB to be able to operate. We do have 8 hours or less to address this issue pending that the PO is able to understand how to set override the sequence and operate on Co - Flow. Lately, power cycling has solved this issue and since 8/22 we have not had to go to site to manually get the actuator unstuck.

Status: Ready for level 3

B = There is a leak on the RB

In this case, it depends on the severity of the leak. In the last three months, the leaks observed were considered, NON severe, that is, that their rate leak is less than approx. 50 ppm per hour from the time the leak started. For example, this leak on 9/10.
Therefore, considering this extreme case, in 8 hours we would have leaked to 400 ppm which is almost 4 times our current alert threshold and borderline acceptable.

Status: Ready for level 3

C = There is a sensor failure in the RB the hinders operation and has to be replaced (likely a component)

As the RB is operating right now, we have increased robustness in mission critical sensors so the RB does not fail when sensors fail. The last two failures that involved a sensor were related to a tmth8 component that failed. In this case, we do not guarantee that mission critical sensors failing would allow us to operate the RB for at least 8 hours.

Status: pending - currently on level 2

D = We have another event (that is not A, B, or C) that makes us go to site

In this case, the events related to D are; a CRS CMP oil regulator failure, and a HTF loop low pressure. Both of them are considered O&M tasks. On both of those cases, we could operate for at least 8 hours until someone would be able to go to site and address the issue.

Status: Ready for level 3

Since one of the events (C) is not ready to be within the 8 hour response time, we would recommend to *staff the site on level two mode until there is evidence that we can address this event within 8 hours or so, or the event does not present itself anymore during a full billing cycle (September is very likely going to be one full month with no C events)*

Path Forward

References

- Indicate any relevant references. Documents, links, etc that are essential to the Analysis should go in sections above. This area is for peripheral awareness. Examples: product manuals, related Analyses, related Tasks.