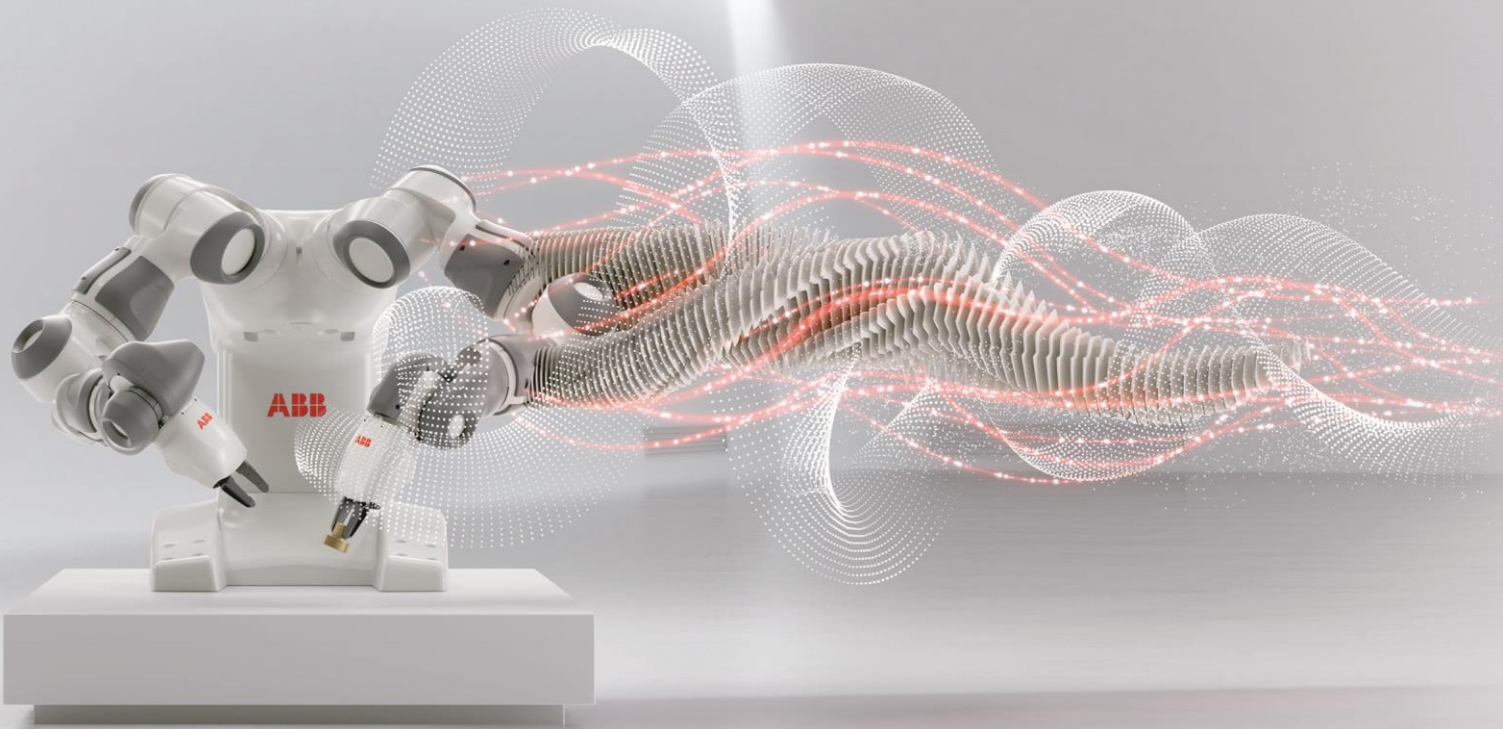

ROBOTICS SERVICE INTELLIGENCE UNIT

Robot Performance Improvement Advisory

Serial Number: Customer1



Robot Description

Date	16 Sep 2019
Robot Serial Number:	XX-XXXXX
Customer:	Customer1
Warranty status:	No warranty
Service status:	ROB_1: Service Not Due ROB_2: Service Not Due
Production Time:	ROB_1: 64780 Hours ROB_2: 69129 Hours
Controller type:	IRC5
RobotWare version:	5.15.09 9024
Manipulator Type:	ROB_1: IRB 6640-235/2.55 ROB_2: IRB 6640-185/2.80
Application	No Information
External Axis:	No
MultiMove:	MultiMove independent

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Report Summary

The robot was analyzed using 3 months data available in Connected service.

The robot was observed for reduced uptime due to avoidable stoppage causing events like Motion supervision, Joint collision, Joint load too high, Joint position error and Brake release error.

- Motion events are highly affecting on Axis5, Axis6 of Rob1 and Axis2, Axis3, Axis5 of Rob2.
- Tool data is within the limit as per load diagrams analysis.
- Torque relative population, activity related population, Utilization relative population and speed relative population found high for multiple Axes of Rob1 and Rob2.
- Estimated lifetime ratio for Rob1 is high compared to Rob2.

It is advised to check for any physical obstruction in motion and/or change the motion configuration

Suboptimal hardware event Motor Angle Reference Warning and Torque Current Reference Error observed. Axis3, Axis5 of Rob1 and Rob2 may have a poor resolver feedback loop, a loose connection or a damaged resolver cable.

DC link voltage is too low for the rectifier on drive communication link 1, drive module 1 observed on week25 and week36. Make sure the mains supply has not been interrupted.

Faulty backup energy bank event observed on 9/13/2019. Check the cables and connectors of the backup energy bank. Check the power supply.

40210: Interrupt removed from queue observed due to suboptimal program performance. Optimize the Rapid program.

1 Area of Improvements

1.1 Maximizing Uptime

1.1.1 Analysis of Robot production time

Robot production time is calculated as the time in which Program state in Executing, Cabinet state in Motor on, and Operating mode in Auto.

Following figure shows the week wise production time for past 3 months.

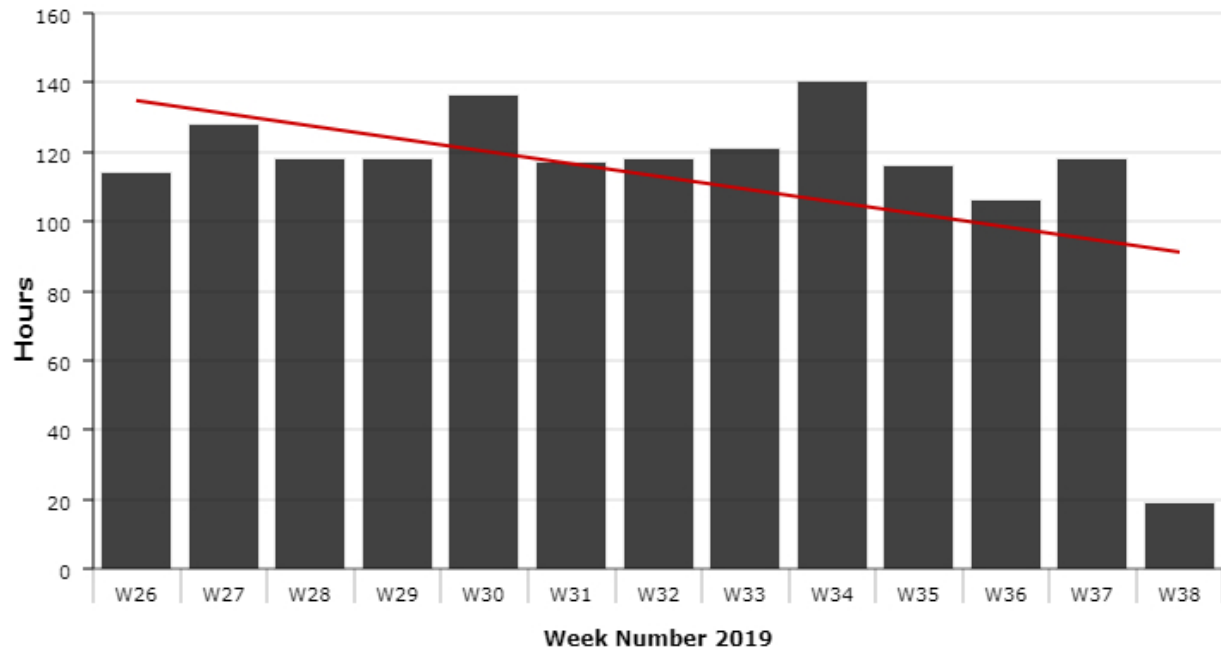


Figure 1

1.1.2 Analysis of motion related stoppage events

The below mentioned events are occurring anywhere in the range of 16 to 125 times in a week. In general, typical stoppage events mentioned in below figure can create an interruption up to 1 minute. In case a smooth production is desirable it is recommended to address these events.

	2019	2019	2019	2019	2019	2019	2019	2019	2019	2019	2019	2019	2019	
	WK	WK	WK	WK	WK	WK	WK	WK	WK	WK	WK	WK	WK	
Events	37	36	35	34	33	32	31	30	29	28	27	26	25	Grand Total
50021-Joint position error	0	0	2	1	2	7	2	2	7	3	5	0	0	31
50055-Joint load	5	5	2	2	2	4	4	5	16	4	4	3	0	56

too high														
50056-Joint collision	18	8	12	6	9	9	2	4	14	24	39	3	12	160
50204-Motion supervision	23	37	14	6	13	20	25	18	74	30	21	33	4	318
50361-Brake release error	10	5	1	1	2	9	2	7	14	8	4	9	2	74
Grand Total	56	55	31	16	28	49	35	36	125	69	73	48	18	639

Figure2

1.1.3 Axis with most 50204: Motion Supervision occurrence

Triggering of the motion supervision may be caused by a collision, incorrect load definition or forces in external process. Motion Supervision has highly affected on Axis5 of Rob1. Refer below statistics of event 50204 for past 3 months.

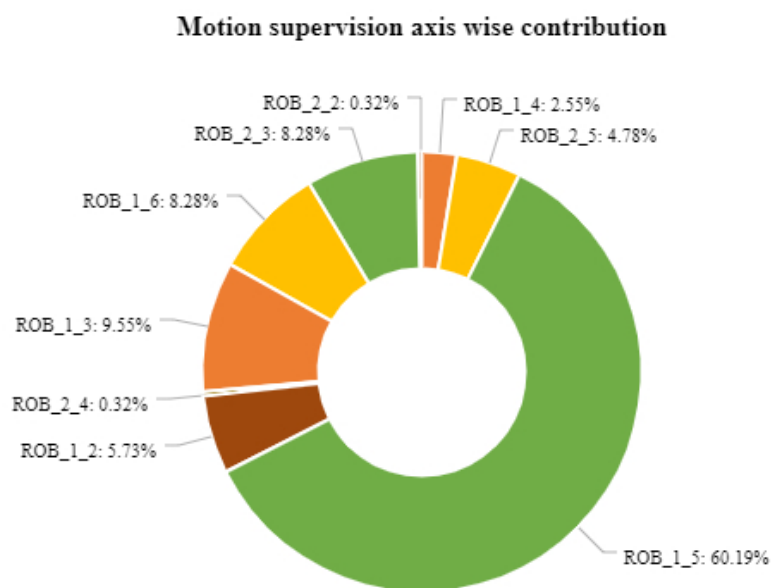


Figure 2

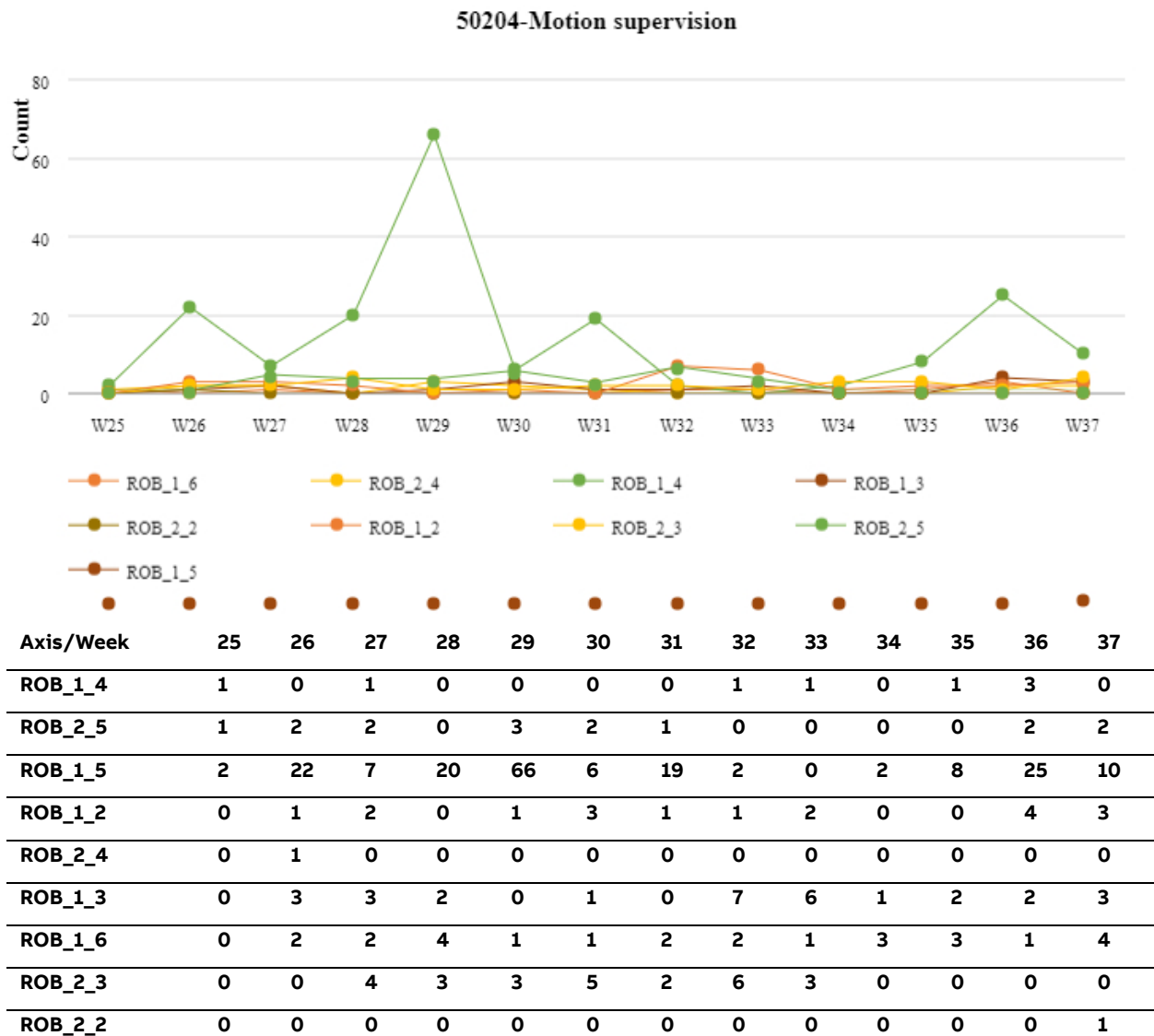


Figure 3

1.1.4 Axis with most 50056: Joint Collision occurrence

Joint collision can happen due to actual torque is higher than ordered while at low or zero speed. It might be caused by jam error (the arm has got stuck) or hardware error. Joint Collision has highly affected on Axis5 and Axis6 of Rob1. Refer below statistics of event 50056 for past 3 months.

Joint collision axis wise contribution

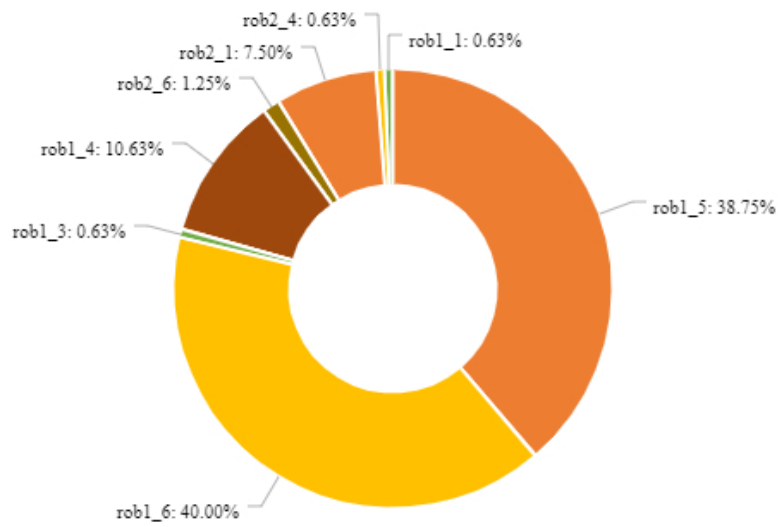
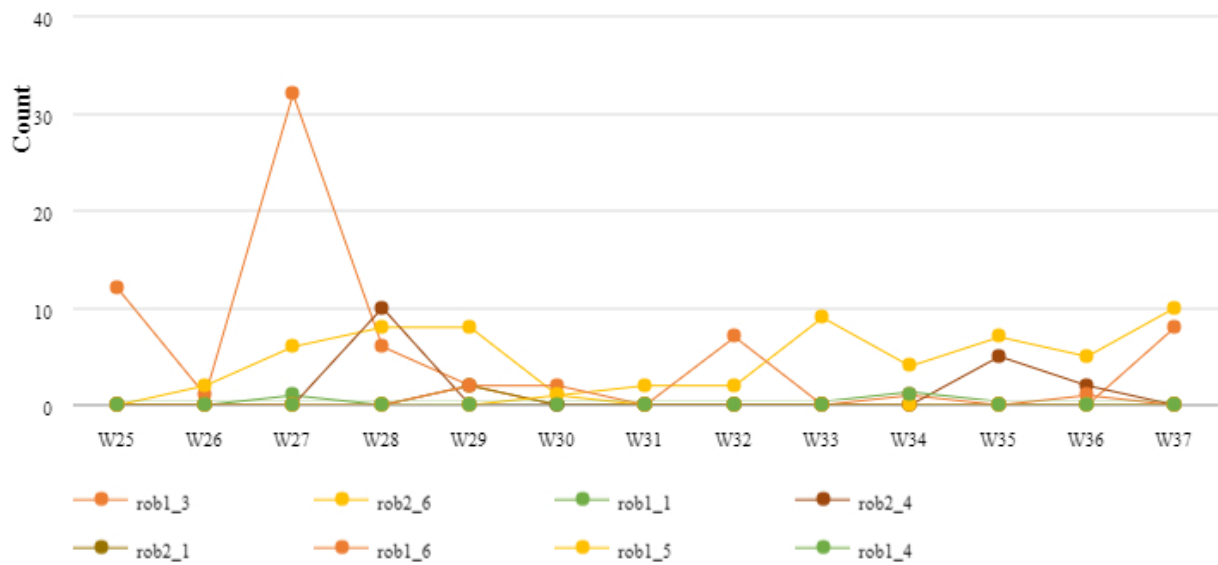


Figure 4

50056-Joint collision



Axis/Week	25	26	27	28	29	30	31	32	33	34	35	36	37
rob1_5	12	1	32	6	2	0	0	0	0	1	0	0	8
rob1_6	0	2	6	8	8	1	2	2	9	4	7	5	10
rob1_3	0	0	1	0	0	0	0	0	0	0	0	0	0
rob1_4	0	0	0	10	0	0	0	0	0	0	5	2	0
rob2_6	0	0	0	0	2	0	0	0	0	0	0	0	0
rob2_1	0	0	0	0	2	2	0	7	0	0	0	1	0
rob2_4	0	0	0	0	0	1	0	0	0	0	0	0	0
rob1_1	0	0	0	0	0	0	0	0	0	1	0	0	0

Figure 5

1.1.5 Axis with most 50055: Joint Load Too High occurrence

Joint load too high can happen due to incorrect load data, too high acceleration, high external process forces, low temperature or hardware error.

Joint load too high has highly affected on Axis6 of Rob1. Refer below statistics of event 50055 for past 3 months.

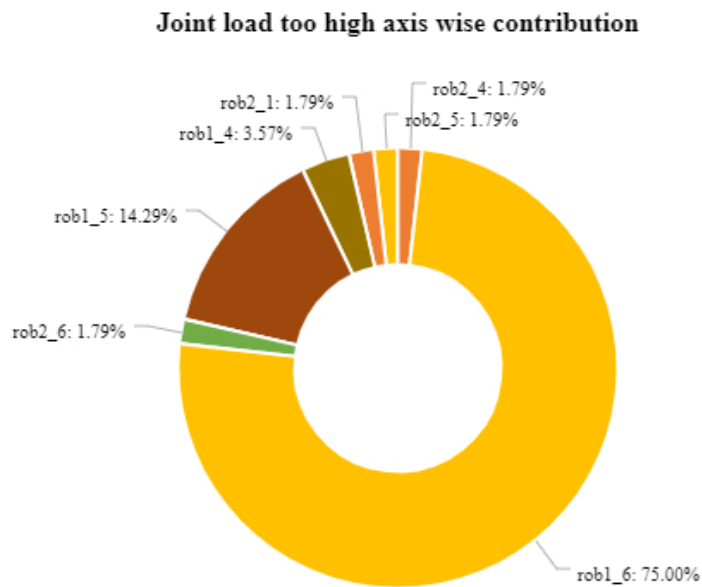
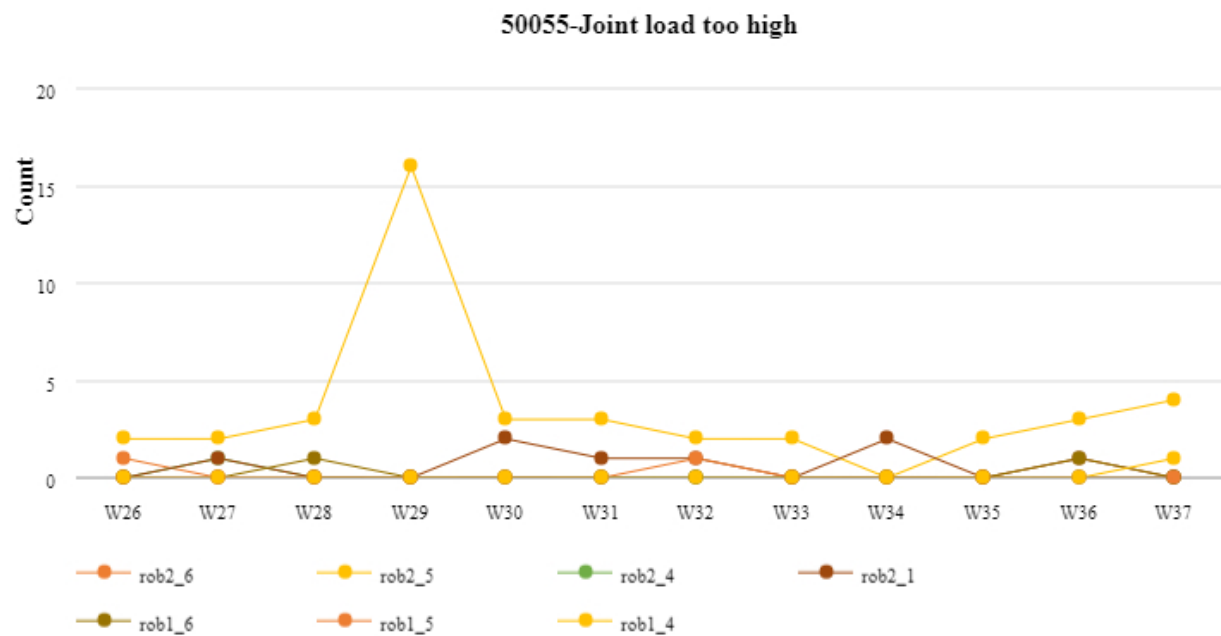


Figure 6



Axis/Week	26	27	28	29	30	31	32	33	34	35	36	37
rob2_4	1	0	0	0	0	0	0	0	0	0	0	0
rob1_6	2	2	3	16	3	3	2	2	0	2	3	4
rob2_6	0	1	0	0	0	0	0	0	0	0	0	0
rob1_5	0	1	0	0	2	1	1	0	2	0	1	0
rob1_4	0	0	1	0	0	0	0	0	0	0	1	0
rob2_1	0	0	0	0	0	0	1	0	0	0	0	0
rob2_5	0	0	0	0	0	0	0	0	0	0	0	1

Figure 7

1.1.6 Axis with most 50021: Joint Position Error occurrence

Joint position error can happen when the actual position of the any of the joint is too far away from the ordered position.
Joint position error has highly affected on Axis3 of Rob2. Refer below statistics of event 50021 for past 3 months.

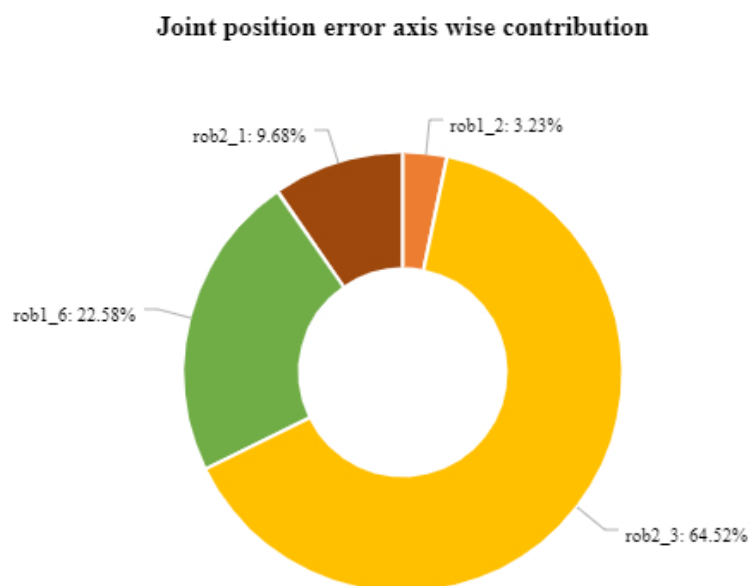


Figure 8

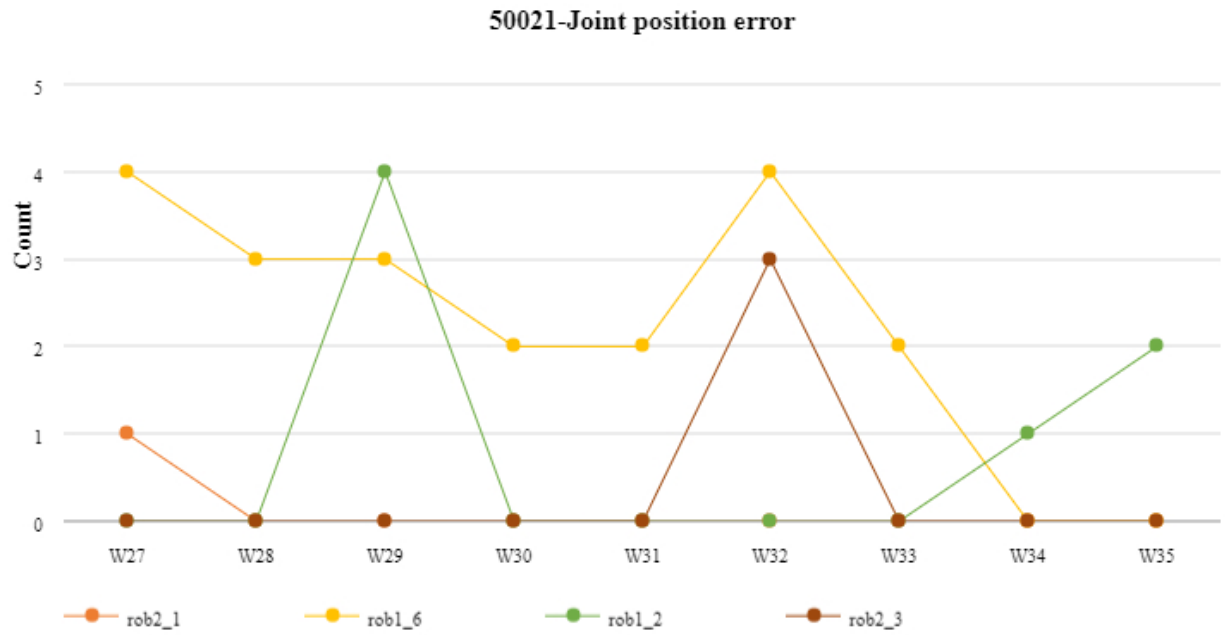


Figure 9

1.1.7 Axis with most 50361: Brake Release Error occurrence

50361: Brake release error happens when too large position error happens with any of the joint after brake release. Brake release error has highly affected on Axis5, Axis6 of Rob1 and Axis2, Axis5 of Rob2 . Refer below statistics of event 50361 for past 3 months.

Brake release error axis wise contribution

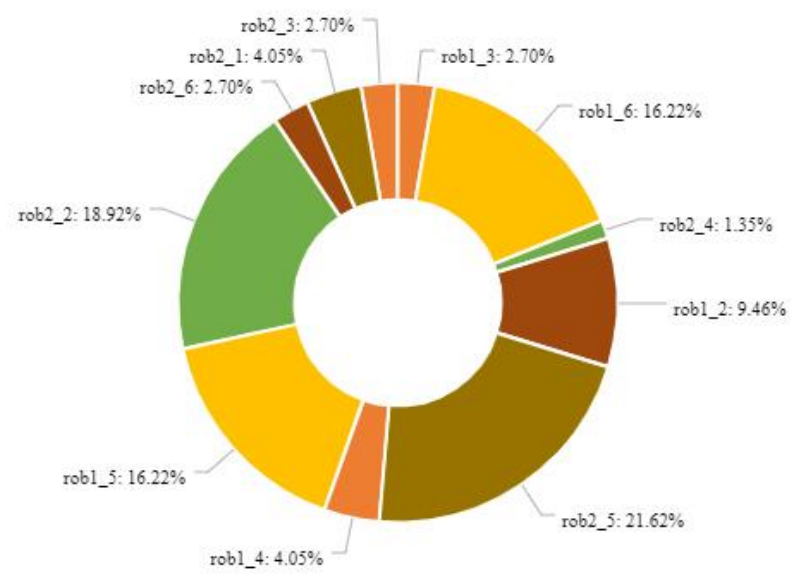
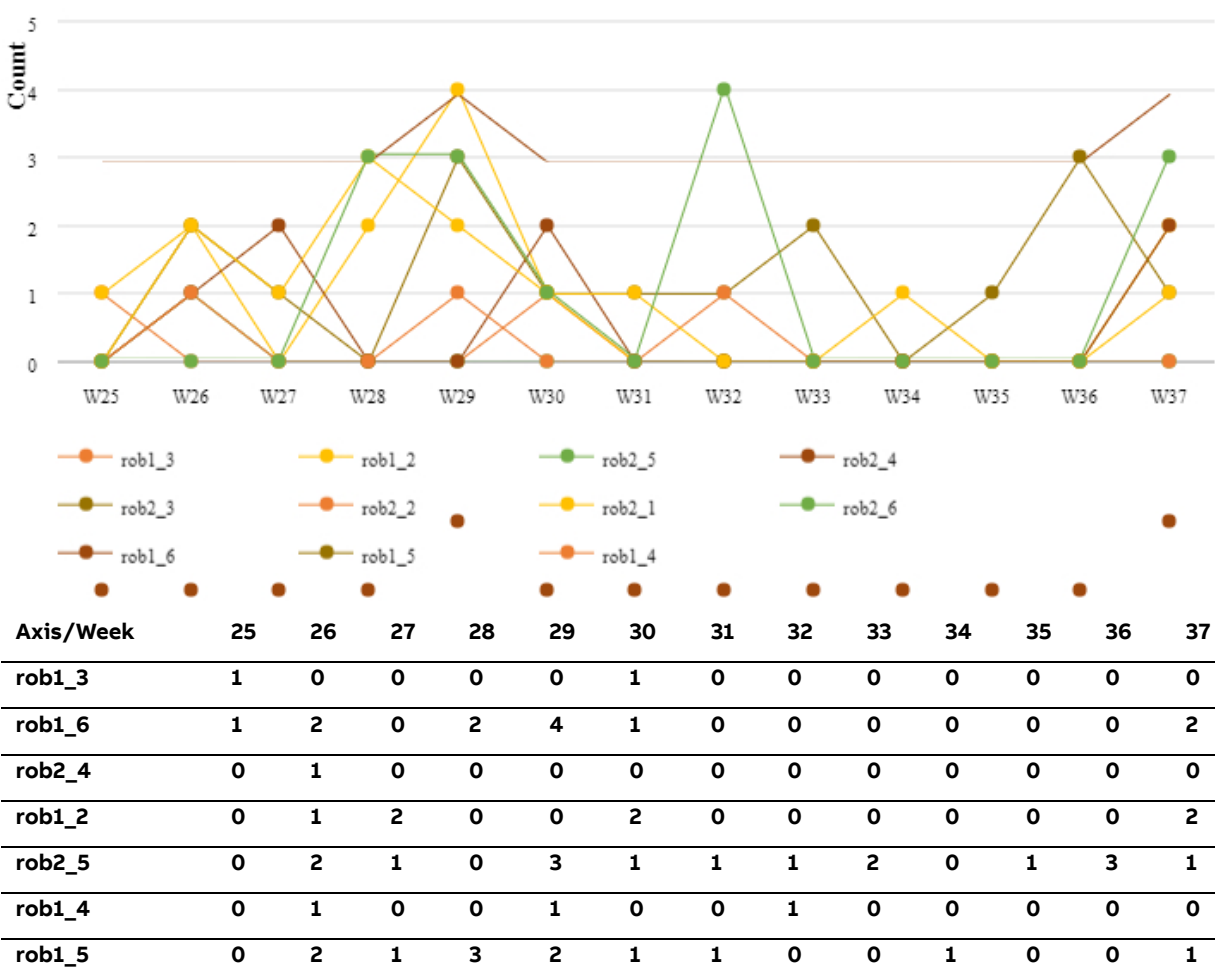


Figure 10

50361-Brake release error



rob2_2	0	0	0	3	3	1	0	4	0	0	0	0	3
rob2_6	0	0	0	0	1	0	0	0	0	0	0	0	1
rob2_1	0	0	0	0	0	0	0	3	0	0	0	0	0
rob2_3	0	0	0	0	0	0	0	0	0	0	0	2	0

Figure 11

1.1.8 Identifying program pointers for stoppage location of motion supervision events

For most of the instances of motion supervision events, the robot is stopping at the below given program pointer position. Refer figure below.

Task	Event Code	Module	Routine	Instructions	Count
T_ROB1	50204	Movement	LegTest_ToPickTop	MoveL tTop45, vRob1_Slow, fine, Box-Tool\WObj:=wobj0;	60
T_ROB2	50204	MainModule	main	WaitTime 0.5;	42
T_ROB1	50204	Movement	SafeMoveTest	MoveL t, v100, fine, BoxTool\WObj:=wobj0;	33
T_ROB2	50204	ProfiSignals	PLC_WaitInfeedBox	WaitTime 0.1;	28
T_ROB2	50204	MOVEMENT	ToSafepos	MoveJ t, v100, fine, BoxTool\WObj:=wobj1;	27
T_ROB1	50204	Movement	Infeed_ToBox	MoveL Offs(tInfeed,0,0,0), vRob1_Slow, fine, BoxTool\WObj:=wobj0;	27
T_ROB1	50204	MainModule	main	WaitTime 0.5;	25
T_ROB1	50204	MainModule	main	WaitTime 3;	25
T_ROB1	50204	Movement	SafeMoveTest	MoveJ tSafe, v100, fine, Box-Tool\WObj:=wobj0;	21
T_ROB2	50204	MOVEMENT	To_EmptyBottom	MoveL tBottomEmpty, vRob2_Slow, fine, Box-Tool\WObj:=wobj1;	21

Figure 12

1.1.9 Identifying program pointers for stoppage location of Joint collision events

For most of the instances of Joint collision events, the robot is stopping at the below given program pointer position. Refer figure below.

Task	Event Code	Module	Routine	Instructions	Count
T_ROB2	50056	MOVEMENT	ToSafepos	MoveJ t, v100, fine, BoxTool\WObj:=wobj1;	5
T_ROB2	50056	MainModule	main	WaitTime 0.5;	5
T_ROB1	50056	MainModule	main	WaitTime 3;	5
T_ROB1	50056	MainModule	main	WaitTime 0.5;	5
T_ROB2	50056	MOVEMENT	ToSafepos	MoveJ tSafe, v100, fine, BoxTool\WObj:=wobj1;	2

1.1.10 Analysis of Tool/Load data

Using latest available robot backup, Load diagram is generated for randomly selected tool/load data. Following are the tool selected for analysis:

Rob1:

PERS tooldata BoxTool := [TRUE,[[0,0,700],[1,0,0,0]],[130.7,[-4.8,-0.1,409.9],[1,0,0,0],41.795,18.022,20.884]];

PERS loaddata box_load := [18,[0,0,0.001],[1,0,0,0],2.6,3.3,0.7];

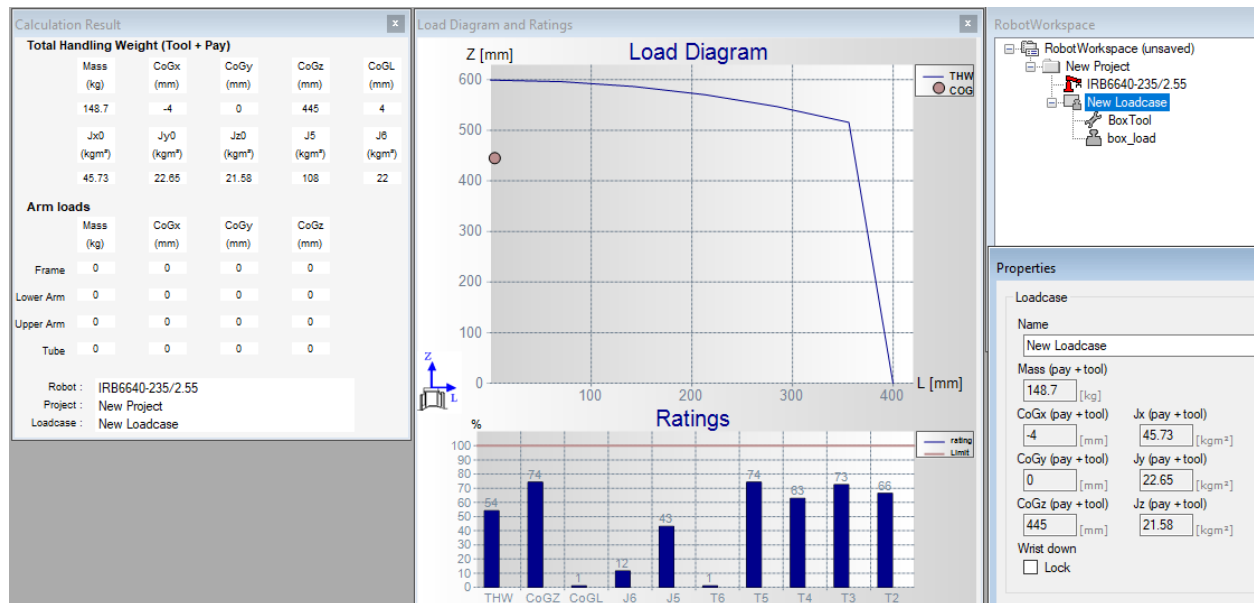


Figure 15

Rob2:

PERS tooldata BoxTool := [TRUE,[[0,0,700],[1,0,0,0]],[130.7,[-4.8,-0.1,409.9],[1,0,0,0],41.795,18.022,20.884]];

PERS loaddata box_load := [18,[0,0,0.001],[1,0,0,0],2.6,3.3,0.7];

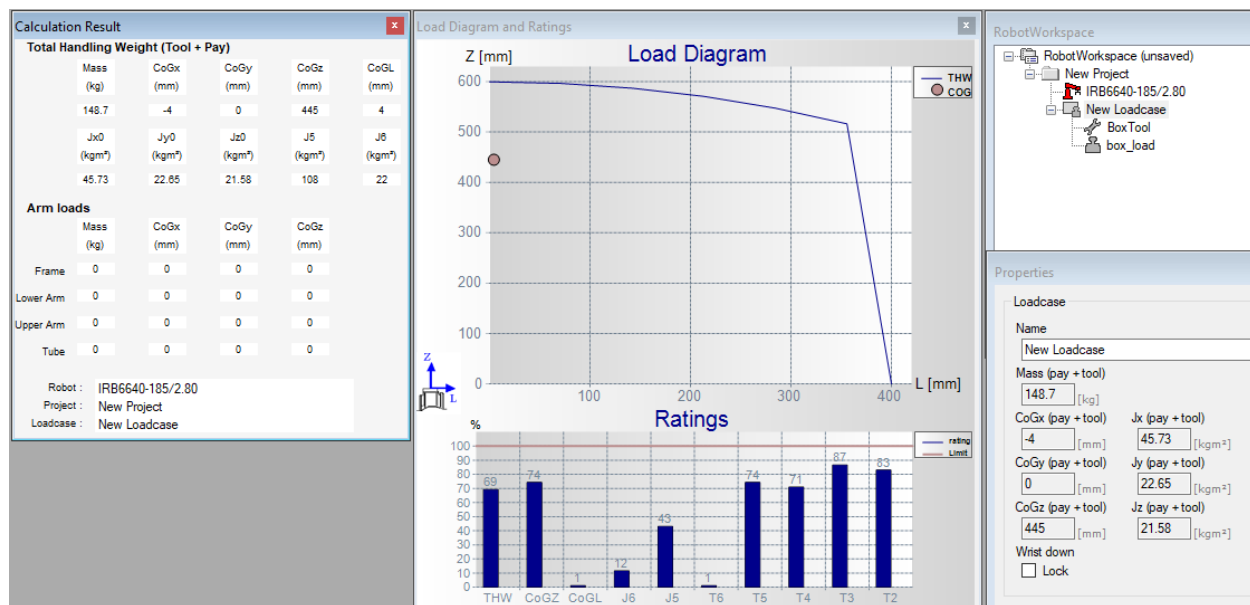


Figure 16

The load diagram and ratings are within the limit. Physically check that load defined are matching with the tool data.

Load Diagram and Ratings:

This window shows the load diagram, center of gravity and ratings for actual load. Ratings are expressed as percentage of max allowed magnitude.

THW = Total Handling Weight

CoGZ = Distance to load diagram in Z-direction from center of gravity

CoGL = Distance to load diagram in L-direction from center of gravity

J5 = Total Mass moments of inertia for axis 5.

J6 = Total Mass moments of inertia for axis 6.

T6-T2 = Static torque axes 2 to 6.

1.1.11 Observations from Robot service assessment data

Population average is calculated based on the usage of particular robot model across the globe.

Rob1

Average activity relative population is high for Axis1 to Axis6.

Average torque relative population is high for Axis4 to Axis6.

Average speed relative population is high for Axis2 to Axis6.

Utilization relative population is high for Axis2 to Axis6.

Please refer below figure.

Calculation Date 9/16/2019
 Serial Number 66-62105
 Mechanical Unit ROB_1
 Robot Type IRB 6640
 RobotWare Release ROBOTWARE_5.15.9024
 Production Time (hours) 64780
 Duty Factor (%) 34
 Population Average Duty Factor (%) 20

Parameter	Axis 1	Axis 2	Axis 3	Axis 4	Axis 5	Axis 6
Activity (%)	37	49	47	45	48	47
Relative distance (%)	7	18	16	18	12	29
Accumulated distance	19710702	50131287	45964500	50462390	33887315	83625015
Estimated lifetime ratio (%)	15	76	87			10
Average speed relative population (%)	133	302	302	263	193	288
Average torque relative population (%)	103	92	106	133	133	141
Utilization relative population (%)	167	525	561	495	357	561
Average activity relative population (%)	185	216	213	253	225	239

Indicators based on population statistics version 8, 3/5/2019 , population size 9788

Figure 17

Rob2:

Average activity relative population is high for Axis4 to Axis6.
 Average torque relative population is high for Axis2, Axis3 to Axis5.
 Average speed relative population is Ok for Rob1.
 Utilization relative population is Ok for Rob1.

Please refer below figure.

Calculation Date 9/16/2019
 Serial Number 66-61317
 Mechanical Unit ROB_2
 Robot Type IRB 6640
 RobotWare Release ROBOTWARE_5.15.9024
 Production Time (hours) 69129
 Duty Factor (%) 34
 Population Average Duty Factor (%) 20

Parameter	Axis 1	Axis 2	Axis 3	Axis 4	Axis 5	Axis 6
Activity (%)	25	30	29	26	29	27
Relative distance (%)	15	17	9	17	16	26
Accumulated distance	27524906	31623768	17299857	32203366	29175934	47306652
Estimated lifetime ratio (%)	0	12	6			0
Average speed relative population (%)	121	100	41	71	77	64
Average torque relative population (%)	44	109	129	79	141	75
Utilization relative population (%)	82	120	85	75	138	69
Average activity relative population (%)	122	131	132	144	137	137

Indicators based on population statistics version 8, 3/5/2019 , population size 9788

Figure 18

1.1.12 Estimated lifetime ratio for Gearbox

The Estimated lifetime ratio tab shows how much of the gearbox lifetime has been used up per axis for each robot in the fleet. This will help to identify robots with high service demand, especially related to gearbox.

Rob1

Estimated lifetime ratio for Axis 1 is 15% for production time 64780 Hours
Estimated lifetime ratio for Axis 2 is 76% for production time 64780 Hours
Estimated lifetime ratio for Axis 3 is 87% for production time 64780 Hours
Estimated lifetime ratio for Axis 6 is 10% for production time 64780 Hours
Refer below figure for details

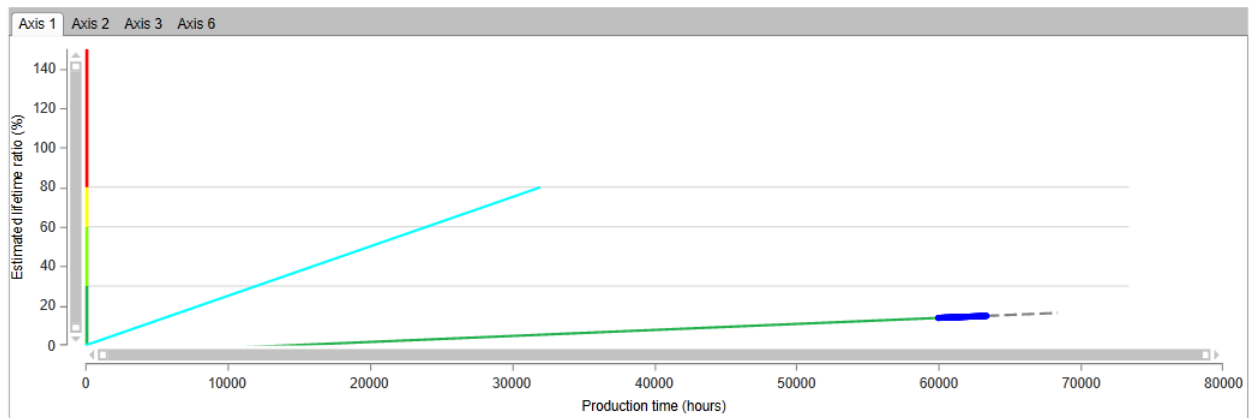


Figure 19

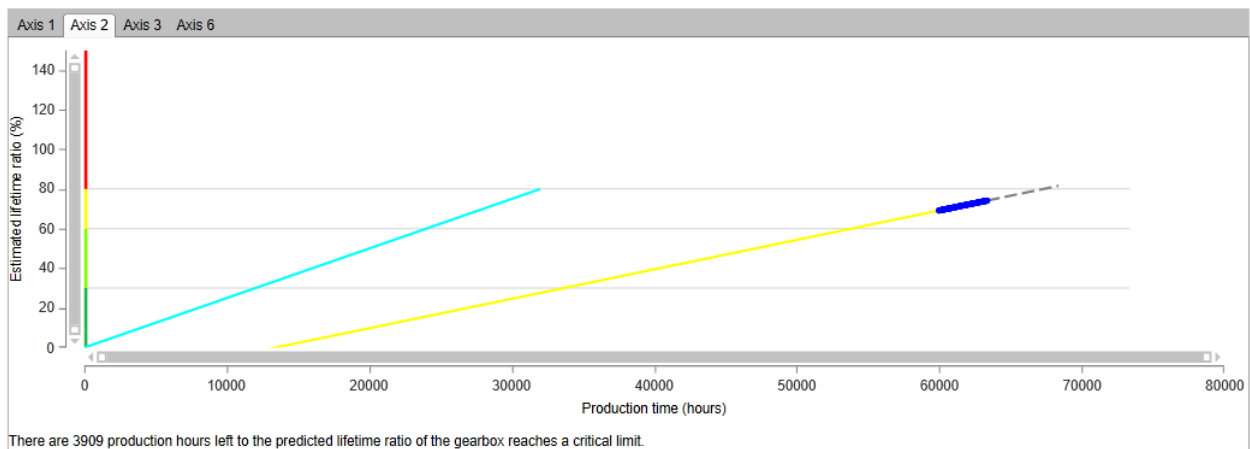


Figure 20

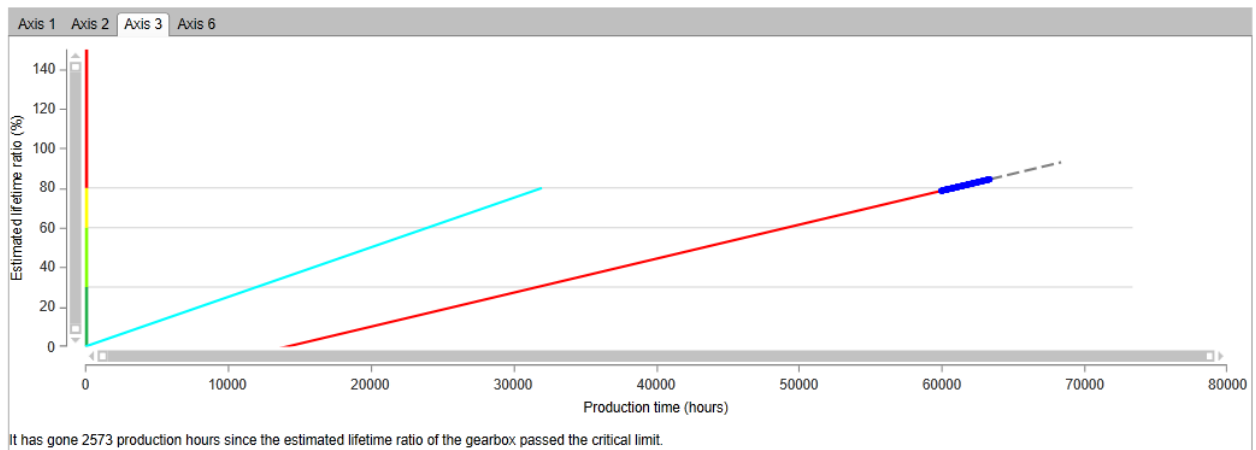


Figure 21

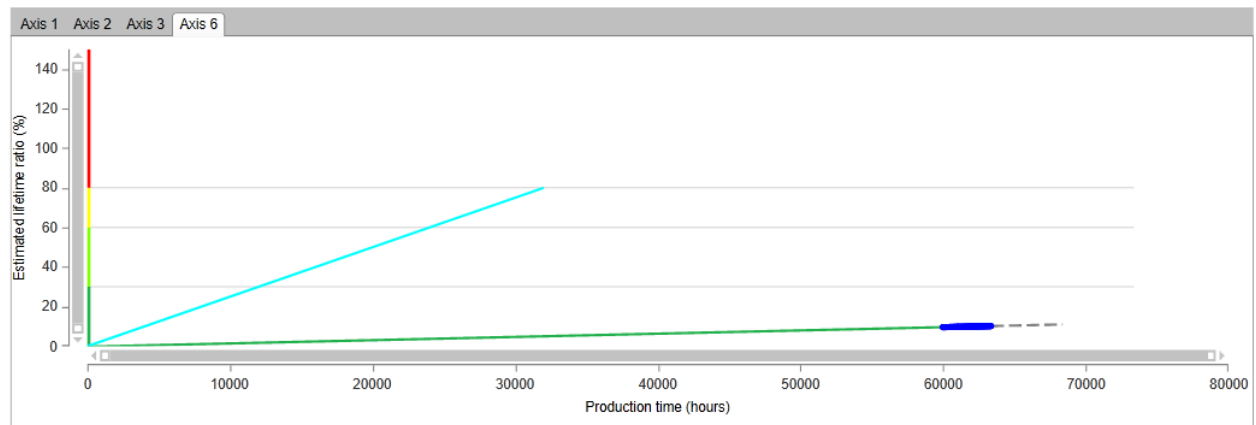


Figure 22

Rob2:

Estimated lifetime ratio for Axis 1 is 0% for production time 17199 Hours
 Estimated lifetime ratio for Axis 2 is 12% for production time 17199 Hours
 Estimated lifetime ratio for Axis 3 is 6% for production time 17199 Hours
 Estimated lifetime ratio for Axis 6 is 0% for production time 17199 Hours
 Refer below figure for details

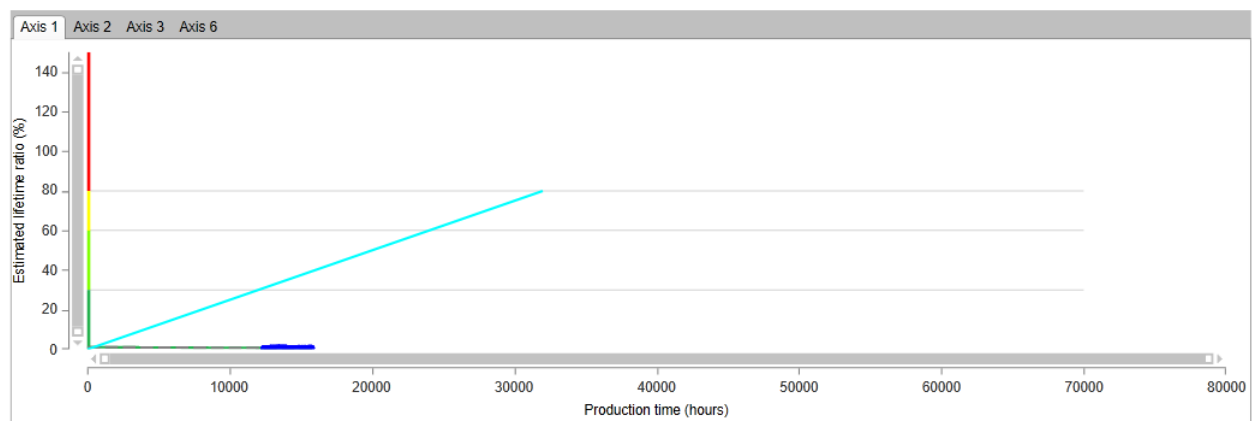


Figure 23

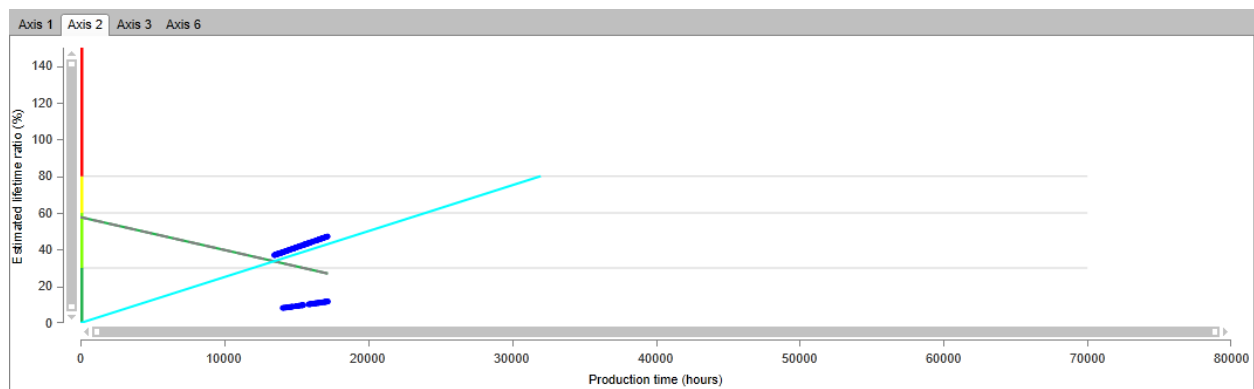


Figure 24

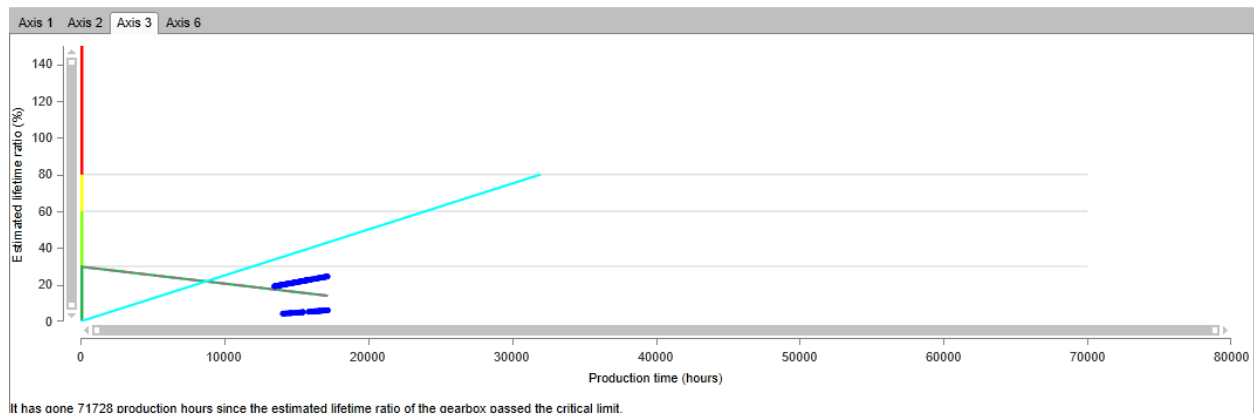


Figure 25

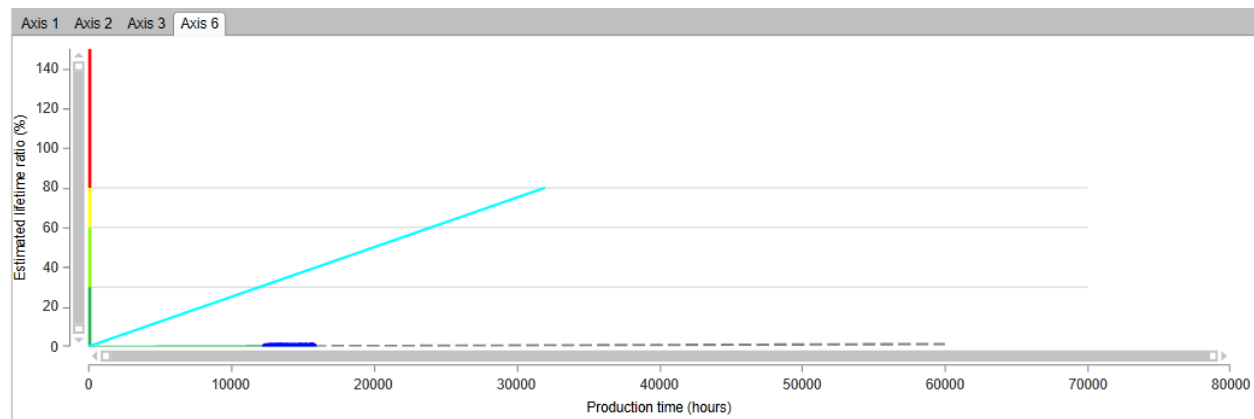
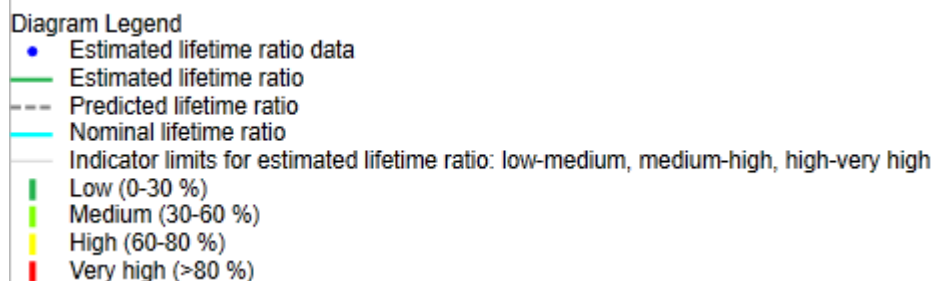


Figure 26



1.1.13 Conclusion

- Motion events are highly affecting on Axis5, Axis6 of Rob1 and Axis2, Axis3, Axis5 of Rob2.
- Tool data is within the limit as per load diagrams analysis.
- Torque relative population, activity related population, Utilization relative population and speed relative population found high for multiple Axes of Rob1 and Rob2.
- Estimated lifetime ratio for Rob1 is high compared to Rob2.

1.2 Improving Suboptimal Hardware Performance

The category of events included here are related to suboptimal hardware performance. Failure to address these issue could lead to robot breakdown in future.

	2019	2019	2019	2019	2019	2019	2019	2019	2019	2019	
	WK	WK	WK	WK	WK	WK	WK	WK	WK	WK	
Events	37	36	35	34	33	32	30	29	26	25	Grand Total
37106- Low backup energy bank voltage level	1	0	0	0	0	0	0	0	0	0	1
37107- Faulty backup energy bank	1	0	0	0	0	0	0	0	0	0	1
39401- Torque Current Reference Error	1	0	0	1	0	2	0	0	2	0	6
39402- Motor Angle Reference Warning	1	1	1	3	1	4	2	1	0	0	14
39460- DC Link Voltage Too Low	0	1	0	0	0	0	0	0	0	1	2
Grand Total	4	2	1	4	1	6	2	1	2	1	24

Figure27

1.2.1 Identifying affected areas for 39460 - DC Link Voltage Too Low

The above-mentioned event observed on week25 and week36

The DC link voltage is too low for the rectifier on drive communication link 1, drive module 1.The system goes to status SYS HALT during the occurrence of the error.

Probable cause for the errors are mentioned below.

- The DC link bus bar may be incorrectly connected or the three-phase mains power may be interrupted while the robot is in the Motors ON state.
- The mains contactor may also have been opened whilst the robot is in Motors ON state (breaking the safety chain). The incoming main power supply may also be too low.

1.2.2 Identifying the affected areas for Motor Angle Reference Warning and Torque Current Reference Error

The above-mentioned event observed 20 times for the past 3 months.

The motor angle reference warning and Torque current reference error is affecting Axis3 and Axis5 of Rob1 and Rob2 connected to drive module 1 and drive module 2.

The above errors can occur because of disturbances due to weak shields in the signal cables. Also the robot may have poor resolver feedback loop, a loose connection or a damaged resolver cable.

1.2.1 Identifying affected areas for Faulty backup energy bank

The event related to backup energy bank was observed on 9/13/2019.

The voltage in the computer unit backup energy bank is too low to be functional. No system data changes will be saved at power of if the error persist. This may be caused by a faulty backup energy bank, cabling or charger.

1.3 Improving Suboptimal Programs

The category of events included here are related to suboptimal programs.

	2019	2019	2019	2019	2019	2019	2019	2019	2019	2019	2019	2019	2019	
	WK	WK	WK	WK	WK	WK	WK	WK	WK	WK	WK	WK	WK	
Events	37	36	35	34	33	32	31	30	29	28	27	26	25	Grand Total
40210- Inter- rupt re- moved from queue	19	14	4	5	9	12	5	10	28	14	6	10	7	143
Grand Total	19	14	4	5	9	12	5	10	28	14	6	10	7	143

Figure28

1.3.1 Identifying the affected areas for 40210: Interrupt removed from queue

The event 40210 occurred 143 times for the past 3 months.

All interrupts have been deleted from the interrupt queue in task T_ROB1 and T_ROB2. No trap routines, connected with the interrupt, may be executed.

Probable cause for the errors are given below

- The program has been stopped.
- A service routine or an event routine may be executing.
- The program is executing in step mode.

2 Recommendations

2.1 Motion Events

- Check that the robot path is properly taught at the Program pointer where the collision is happening and its motion is not obstructed by any external object. Fine tune the motion program. Reduce programmed speed if required.
- Check the cable harness on robots, check if that restrict the movement of robot arms.
- Please make sure that motion contain the correct tool argument and is preceded by correct load data in grip load instruction.
- Check the gearbox oil for any metallic contamination
- Check for any undesirable play in the gearboxes, rectify if found
- Make sure that motor and brakes cables are not damaged and insulation is not deteriorated.

2.2 39460: DC Link Voltage Too Low

- Make sure the DC link bus bar is correctly connected.
- Make sure the mains supply has not been interrupted.
- Make sure the safety chain has not been broken.
- Make sure the Drive Module Power Supply output voltage is within acceptable limits as specified in the Product Manual.

2.3 Motor Angle Reference Warning and Torque Current Reference Error

- Axis3 and Axis5 of Rob1 and Rob2 may have a poor resolver feedback loop, a loose connection or a damaged resolver cable can be a possible reason.
- Check the resolver grounding for these axes. Check the torque and speed signal with Test Signal Viewer. If you can see a large oscillation in the signals at the same time the errors occur, this indicates that there is a problem with the shielding and grounding of the system.

2.4 Faulty backup energy bank

Before working on the system, perform a controlled shutdown to ensure all system data is correctly saved.

- Check the cables and connectors of the backup energy bank.
- Check the backup energy bank.
- Check the power supply.
- Replace the faulty unit if required.

3 Connected Services Recommendations

Prediction Enabled	Enabled
KPI Subscription Enabled	Enabled
Auto Backups Enabled	Enabled
Auto backups created as per schedule	Yes
SIS active	Enabled
MCC status	No Data
Service port communication	Ok

Figure 29

4 Appendix

4.1 Service Information

Mechanical Unit	Remaining Time (Days)	Next Service (Date)	Remaining Production Time (Hours)
ROB_1	362	2020-09-13	11961.76
ROB_2	362	2020-09-13	11961.77

Figure 30

4.2 Evenlog for Past 3 Months



Microsoft Excel
Worksheet

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