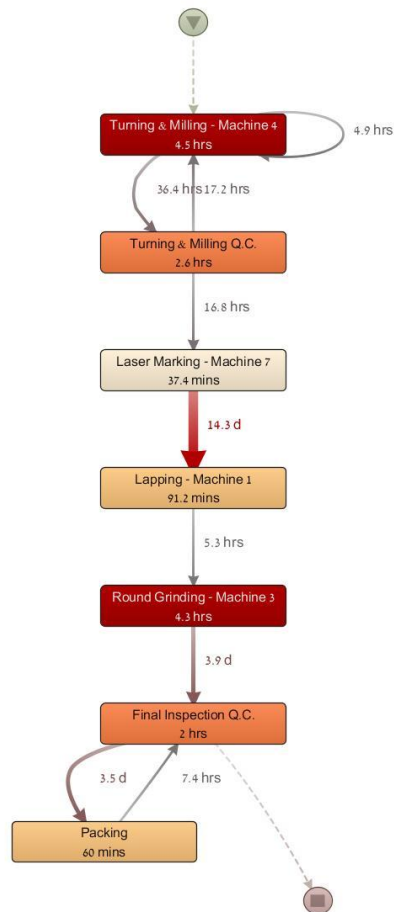
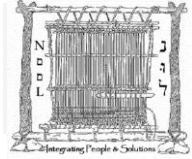


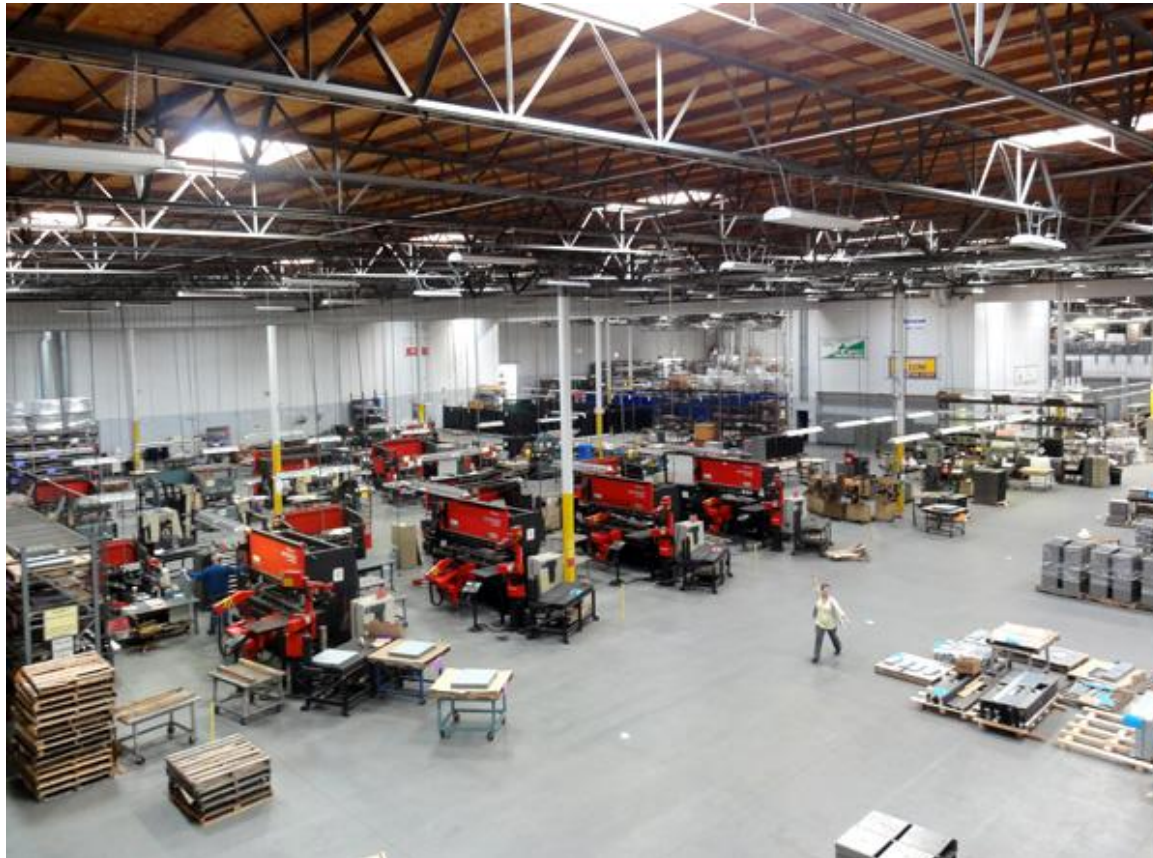
Production Analysis

With Process Mining Technology





The Production Floor



- Departments
 - Workers
 - Work Centers
 - Operations
 - Machines
 - Manual Work

The Planned Routing

Routings - Demo Company - tabula

File View Favorites Mail Edit Database Design Tools Macros Navigation Help

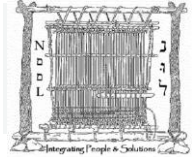
Routing Description

Cable Head

Operations in Routing

Step	Operation	Operation Descrip.	Work Cell	WorkC Description	To W	Bin	MRP-Prod	MRP-Production Qty	MRP %D
10	018	Turning & Milling - Machine 5	004	Machine 5 - Tur			000:00	0	0
15	024	Turning & Milling Q.C.	001	Quality Check 1			000:00	0	0
20	010	Laser Marking - Machine 7	009	Machine 7- Lase			000:00	0	0
30	019	Lapping - Machine 1	003	Machine 1 - Lap			000:00	0	0
40	021	Round Grinding - Machine 2	002	Machine 2 - Rou			000:00	0	0
50	022	Final Inspection Q.C.	001	Quality Check 1			000:00	0	0
60	013	Packing	007	Packing			000:00	0	0

Alternate Operations in Routing Required Analyses



Production Reporting

Reporting Production Details - Demo Company - tabula

File View Favorites Mail Edit Database Design Tools Macros Navigation Help

Reporting Production Details

Reporting Production Details

Report No. 13

Date * 11/14/12

Work Order * 112233

Part Number * 2012

Work Order Qty 2

Operation 018

Work Cell 004

Quantities Times Details Form Misc.

Start Time 08:15

End Time 12:30

Span 004:15

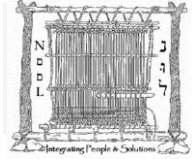
Start Labor 00:00

End Labor 00:00

Labor Span 000:00

Reporting Workers Manual Issues to Work Order Serial Numbers in Transaction Auto Recording of Serial Nos. Prod. Complete (Warehouse Entry) Report Defective Parts

Employee ID	Employee Name	Start Lab	End Lab	Span	Shift
0		00:00	00:00	000:00	



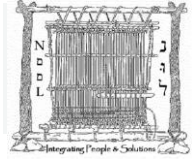
Analyzing Production Reports

With

Disco

Example Deliverables

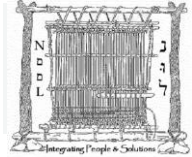




Some Possible Deliverables

- A process map of the executed production processes
- Bottlenecks
- Focused analysis of:
 - ▶ Breakdowns
 - ▶ Rework
 - ▶ Rejected
 - ▶ Long idle times
- Comparison of workers performance
- Analyzing transfer of parts from production floor to subcontractor*.

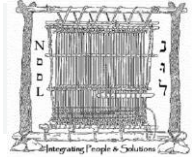
* To be published in a separate presentation



The data Source

- Production reports data are exported from the ERP or MES

	A	B	C	D	E	F	G	
1	Work Order ID	Operation	Work Cell	Machine Start Time	Machine End Time	Span	Work Order Qty	P
2	Case 87	Turning & Milling - Machine 4	Machine 4 - Turning & Milling	12/02/12 10:47	12/02/12 17:55	007:08	720	A
3	Case 87	Turning & Milling - Machine 4	Machine 4 - Turning & Milling	12/02/12 19:55	13/02/12 01:06	005:11	720	A
4	Case 87	Turning & Milling - Machine 4	Machine 4 - Turning & Milling	13/02/12 01:07	13/02/12 06:52	005:45	720	A
5	Case 87	Turning & Milling Q.C.	Quality Check 1	13/02/12 06:50	13/02/12 08:01	001:11	720	A
6	Case 87	Turning & Milling - Machine 4	Machine 4 - Turning & Milling	13/02/12 15:57	13/02/12 15:57	000:00	720	A
7	Case 87	Turning & Milling - Machine 4	Machine 4 - Turning & Milling	13/02/12 16:26	13/02/12 20:00	003:34	720	A
8	Case 87	Turning & Milling - Machine 4	Machine 4 - Turning & Milling	13/02/12 19:49	13/02/12 23:44	003:55	720	A
9	Case 87	Turning & Milling - Machine 4	Machine 4 - Turning & Milling	13/02/12 23:43	14/02/12 06:41	006:58	720	A
10	Case 87	Turning & Milling Q.C.	Quality Check 1	14/02/12 07:28	14/02/12 07:46	000:18	720	A
11	Case 87	Turning & Milling - Machine 4	Machine 4 - Turning & Milling	14/02/12 08:03	14/02/12 17:46	009:43	720	A
12	Case 87	Turning & Milling - Machine 4	Machine 4 - Turning & Milling	14/02/12 17:59	14/02/12 19:52	001:53	720	A
13	Case 87	Turning & Milling - Machine 4	Machine 4 - Turning & Milling	14/02/12 19:54	15/02/12 06:42	010:48	720	A
14	Case 87	Turning & Milling - Machine 4	Machine 4 - Turning & Milling	15/02/12 06:49	15/02/12 17:49	011:00	720	A
15	Case 87	Turning & Milling Q.C.	Quality Check 1	15/02/12 06:54	15/02/12 07:26	000:32	720	A
16	Case 87	Turning & Milling - Machine 4	Machine 4 - Turning & Milling	15/02/12 18:20	15/02/12 19:51	001:31	720	A



The Data in Disco

- The Production reports data are configured and imported for process mining with Disco

Disco - Purchasing Demo

Enterprise
dafnal@nool.co.il

Disco

Work Order ID

column is used

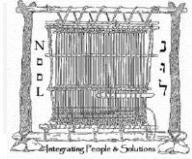
Case

	Work Order ID	Operation	Work Cell	Machine Start Time	Machine End Time	Span	Wd
1	Case 87	Turning & Milling - Machine 4	Machine 4 - Turning & Milling	2012/02/12 10:47:00	2012/02/12 17:55:00	007:08	720
2	Case 87	Turning & Milling - Machine 4	Machine 4 - Turning & Milling	2012/02/12 19:55:00	2012/02/13 01:06:00	005:11	720
3	Case 87	Turning & Milling - Machine 4	Machine 4 - Turning & Milling	2012/02/13 01:07:00	2012/02/13 06:52:00	005:45	720
4	Case 87	Turning & Milling Q.C.	Quality Check 1	2012/02/13 06:50:00	2012/02/13 08:01:00	001:11	720
5	Case 87	Turning & Milling - Machine 4	Machine 4 - Turning & Milling	2012/02/13 15:57:00	2012/02/13 15:57:00	000:00	720
6	Case 87	Turning & Milling - Machine 4	Machine 4 - Turning & Milling	2012/02/13 16:26:00	2012/02/13 20:00:00	003:34	720
7	Case 87	Turning & Milling - Machine 4	Machine 4 - Turning & Milling	2012/02/13 19:49:00	2012/02/13 23:44:00	003:55	720
8	Case 87	Turning & Milling - Machine 4	Machine 4 - Turning & Milling	2012/02/13 23:43:00	2012/02/14 06:41:00	006:58	720
9	Case 87	Turning & Milling Q.C.	Quality Check 1	2012/02/14 07:28:00	2012/02/14 07:46:00	000:18	720
10	Case 87	Turning & Milling - Machine 4	Machine 4 - Turning & Milling	2012/02/14 08:03:00	2012/02/14 17:46:00	009:43	720
11	Case 87	Turning & Milling - Machine 4	Machine 4 - Turning & Milling	2012/02/14 17:59:00	2012/02/14 19:52:00	001:53	720
12	Case 87	Turning & Milling - Machine 4	Machine 4 - Turning & Milling	2012/02/14 19:54:00	2012/02/15 06:42:00	010:48	720
13	Case 87	Turning & Milling - Machine 4	Machine 4 - Turning & Milling	2012/02/15 06:49:00	2012/02/15 17:49:00	011:00	720
14	Case 87	Turning & Milling Q.C.	Quality Check 1	2012/02/15 06:54:00	2012/02/15 07:26:00	000:32	720
15	Case 87	Turning & Milling - Machine 4	Machine 4 - Turning & Milling	2012/02/15 18:20:00	2012/02/15 19:51:00	001:31	720
16	Case 87	Turning & Milling - Machine 4	Machine 4 - Turning & Milling	2012/02/15 19:51:00	2012/02/15 23:36:00	003:45	720
17	Case 87	Turning & Milling - Machine 4	Machine 4 - Turning & Milling	2012/02/15 23:47:00	2012/02/16 06:39:00	006:52	720
18	Case 87	Turning & Milling - Machine 4	Machine 4 - Turning & Milling	2012/02/16 06:50:00	2012/02/16 08:36:00	001:46	720
19	Case 87	Turning & Milling - Machine 4	Machine 4 - Turning & Milling	2012/02/16 07:09:00	2012/02/16 16:06:00	008:57	720
20	Case 87	Turning & Milling - Machine 4	Machine 4 - Turning & Milling	2012/02/16 20:02:00	2012/02/17 06:51:00	010:49	720
21	Case 87	Turning & Milling - Machine 4	Machine 4 - Turning & Milling	2012/02/17 05:21:00	2012/02/17 11:21:00	006:00	720
22	Case 87	Turning & Milling Q.C.	Quality Check 1	2012/02/17 07:00:00	2012/02/17 07:35:00	000:35	720
23	Case 87	Turning & Milling Q.C.	Quality Check 1	2012/02/17 11:17:00	2012/02/17 11:23:00	000:06	720
24	Case 87	Turning & Milling - Machine 4	Machine 4 - Turning & Milling	2012/02/18 13:15:00	2012/02/18 23:15:00	010:00	720
25	Case 87	Turning & Milling - Machine 4	Machine 4 - Turning & Milling	2012/02/18 22:10:00	2012/02/19 06:48:00	008:38	720
26	Case 87	Turning & Milling - Machine 4	Machine 4 - Turning & Milling	2012/02/19 06:54:00	2012/02/19 16:04:00	009:10	720
27	Case 87	Turning & Milling - Machine 4	Machine 4 - Turning & Milling	2012/02/19 16:25:00	2012/02/19 23:46:00	007:21	720

Cancel

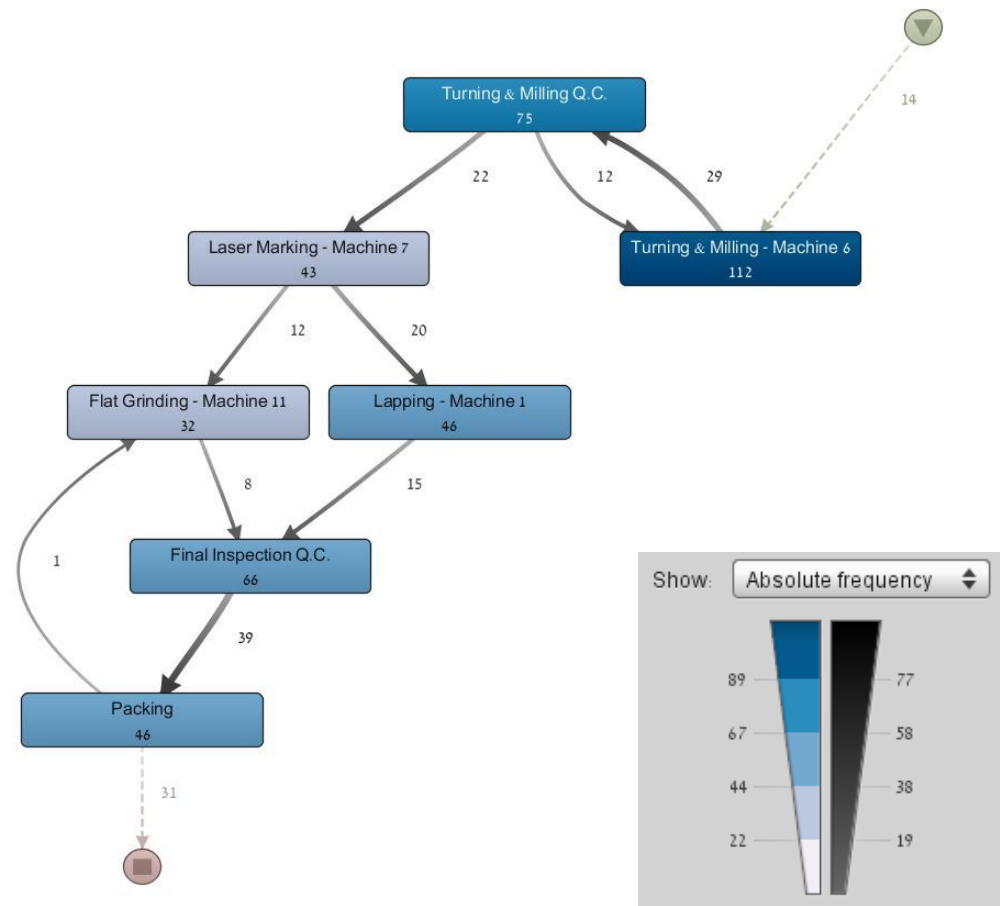
Ready to start import

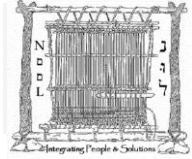
Start import



The Process in Reality

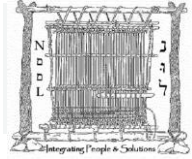
- Operations are represented by the boxes
- The arrows display the flow between operations
- Frequencies are displayed in the numbers at the arcs and in the operations
- The thickness of the arrows and the coloring of the operations visually support these numbers.





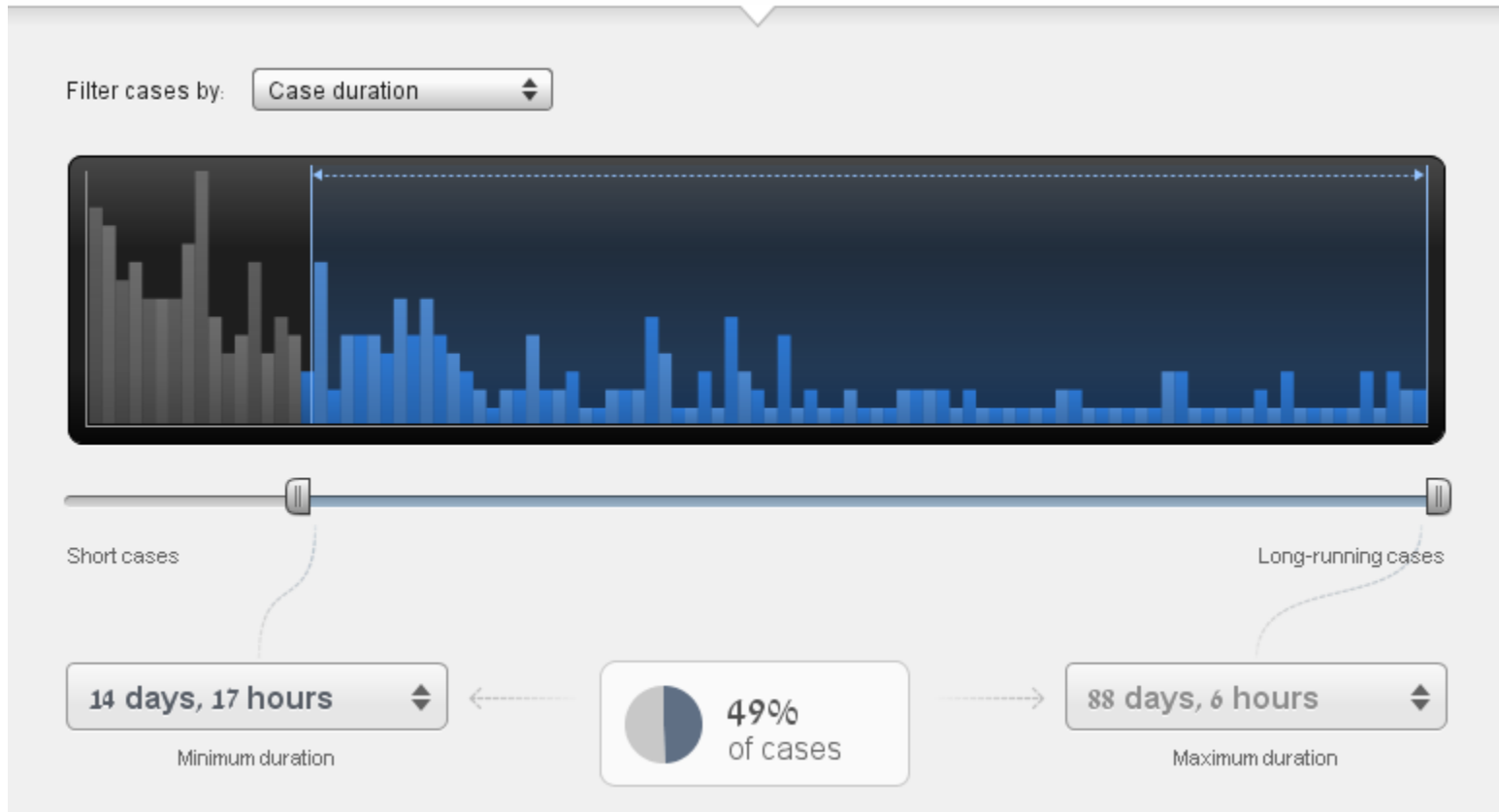
Work Orders Analysis

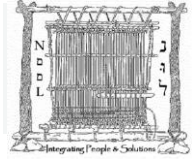




Locating the Slow Work Orders

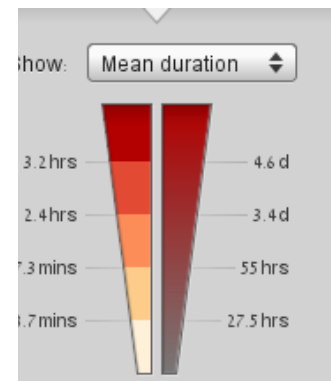
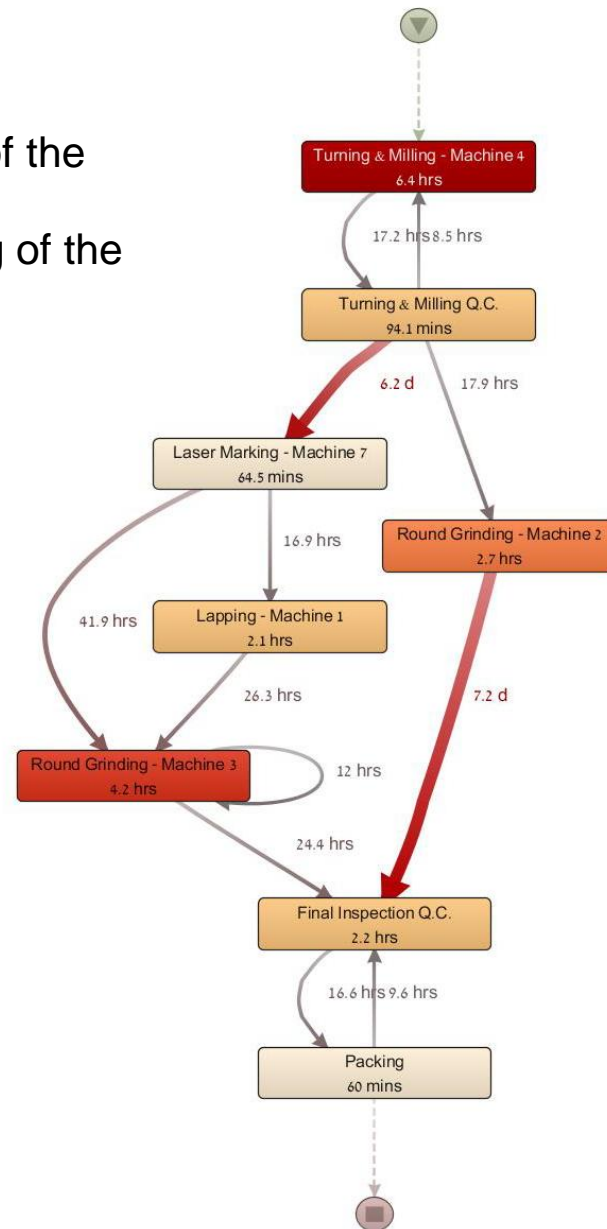
- The **Performance filter** is used to retrieve the desired work orders by duration

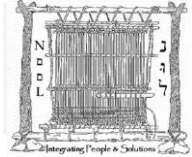




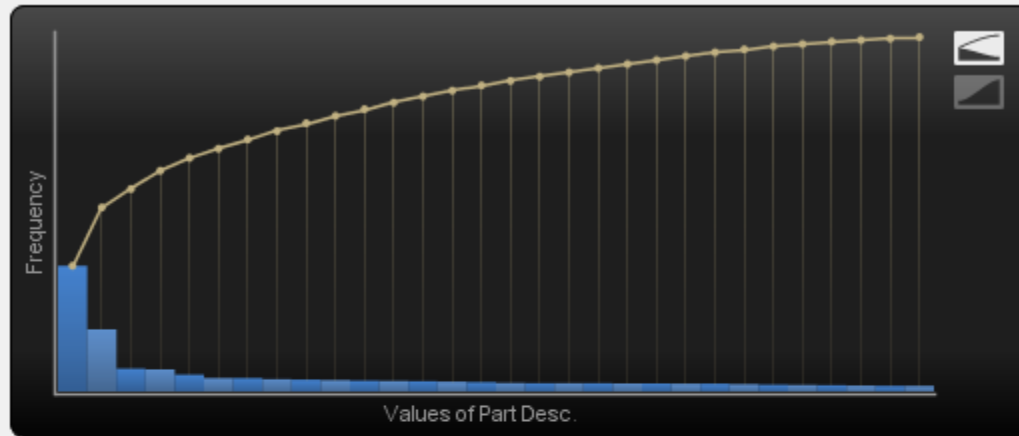
The Process Model of the Slow Work Orders

- The numbers represent the mean duration of the operations and the idle time between them.
- The thickness of the arrows and the coloring of the operations visually support these numbers.





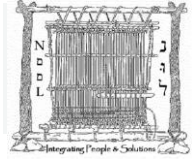
Statistics of the Products in the Slow Work Orders



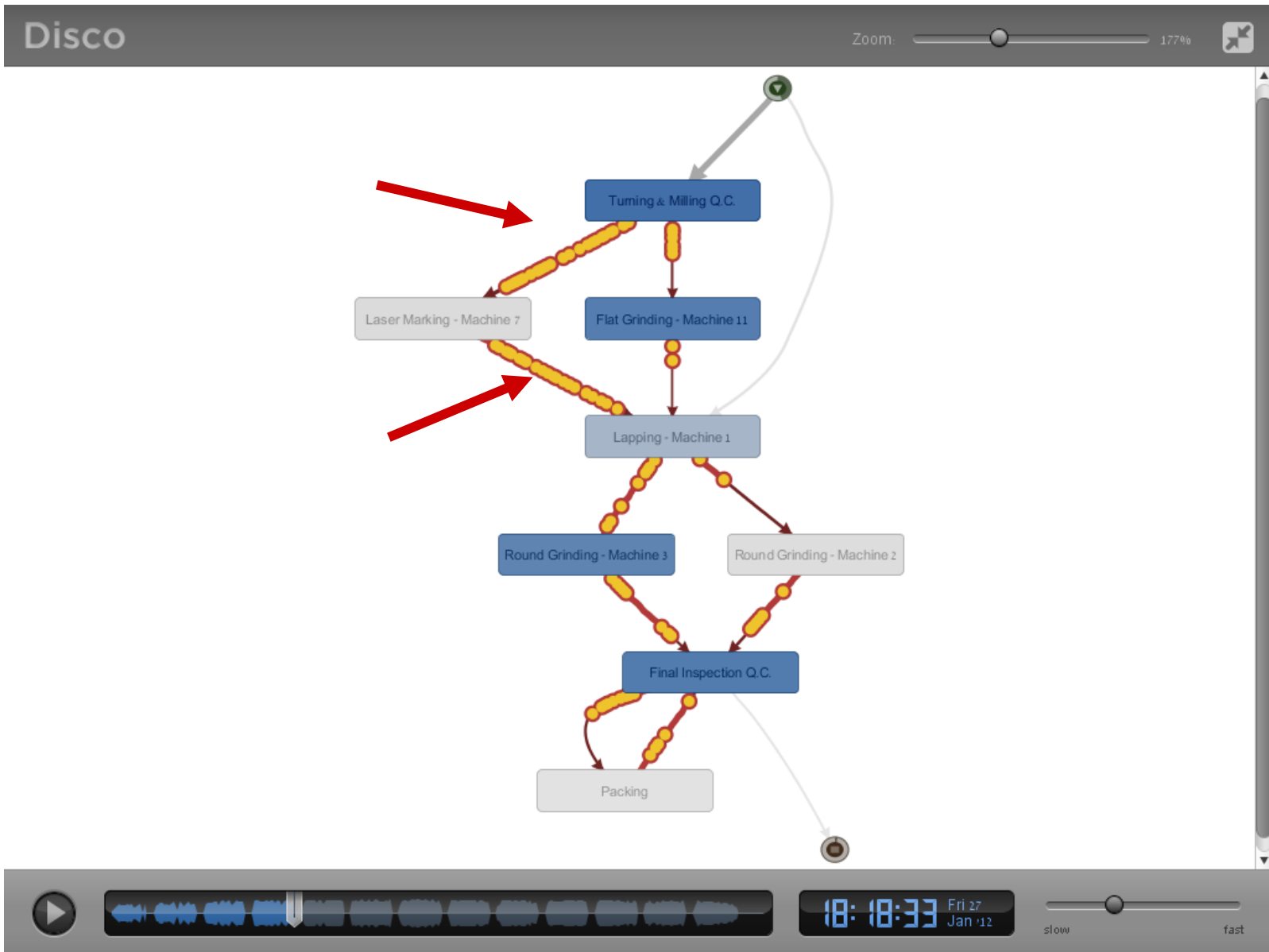
Values	30
Minimal frequency	14
Mean frequency	111.43
Maximal frequency	1,161
Frequency std. deviation	221.7

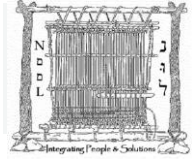
All values (30) First in case (30) Last in case (30)

Value	Frequency	Relative frequency	
Cable Head	1161	34.73 %	
Ballnut	555	16.6 %	
Spur Gear	178	5.32 %	
Punch Holder	173	5.17 %	
Plug	122	3.65 %	
Housing	89	2.66 %	
Adapter	89	2.66 %	
Gauge	79	2.36 %	
Spindle	75	2.24 %	
Piston	70	2.09 %	
Drill	64	1.91 %	
Spinner	62	1.85 %	
Socket	60	1.79 %	
Punch Plate	54	1.62 %	



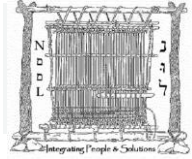
Demonstrating the Bottlenecks with Animation



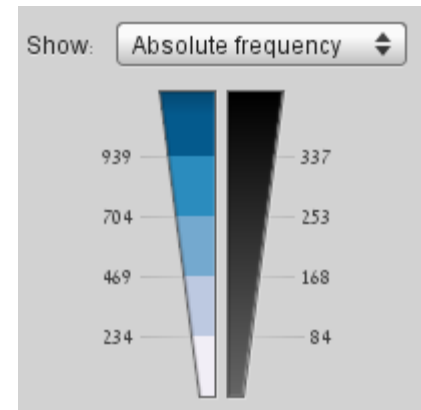
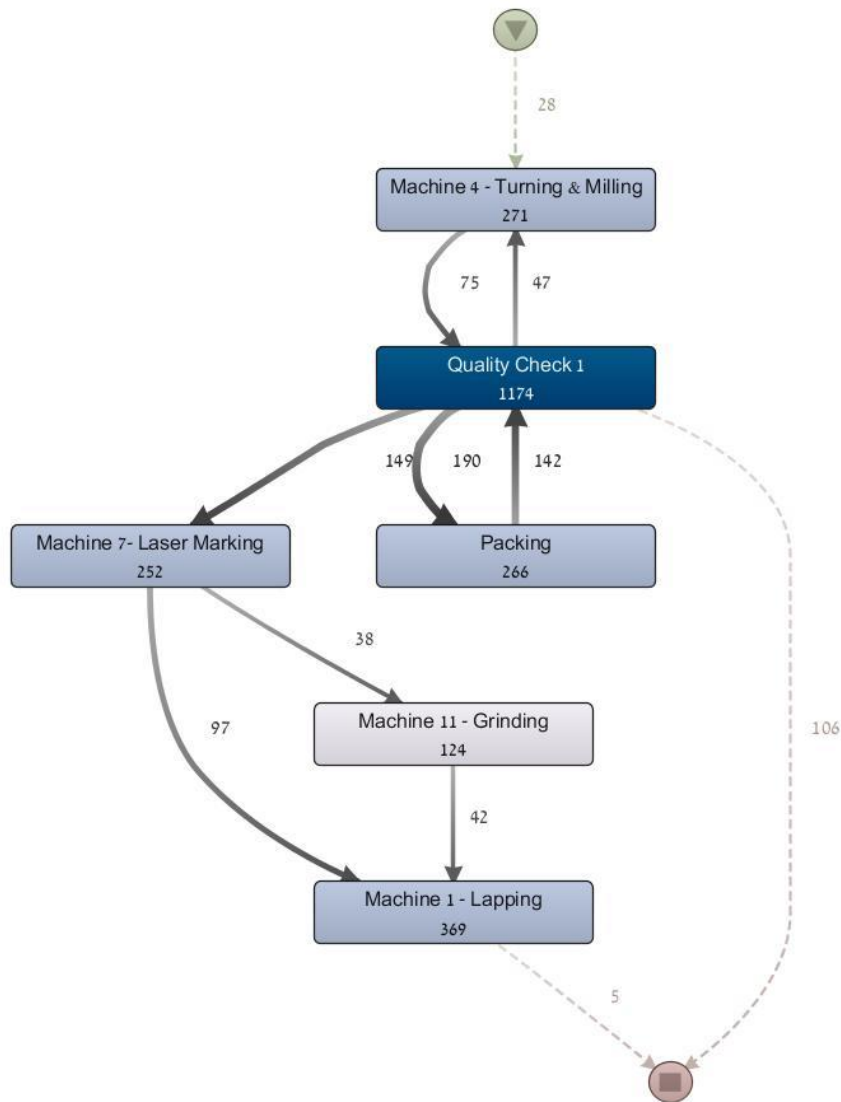


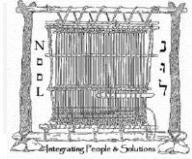
Analysis of Work Cells





Transferring the Work Orders





Analysis of Performance by Waiting Times

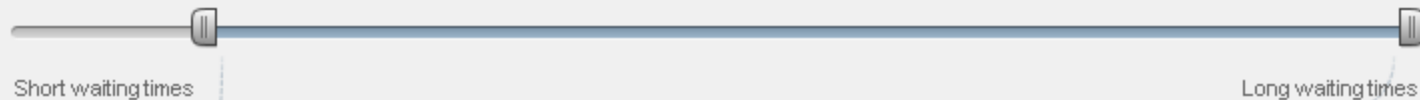
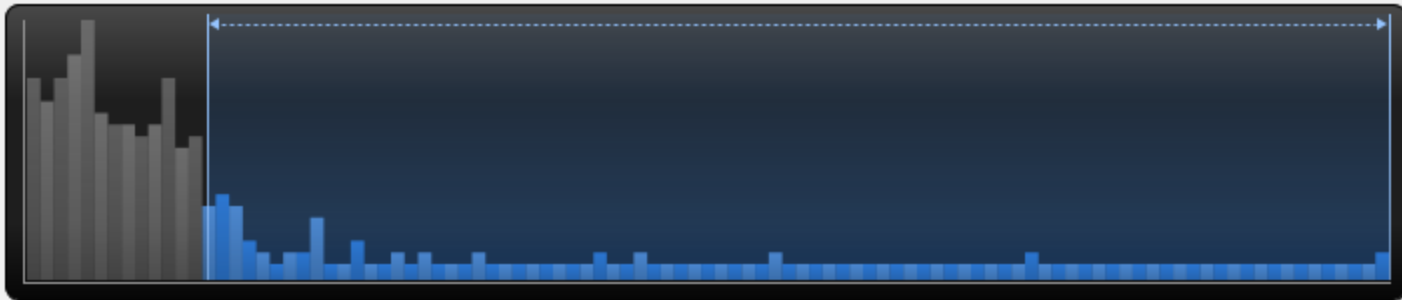


Performance

Filters cases by performance

Filter cases by:

Mean waiting time



2 days, 1 hour

Minimum waiting time

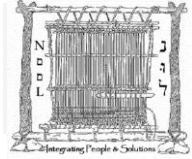


16%
of cases

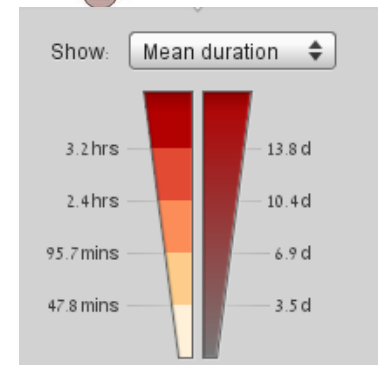
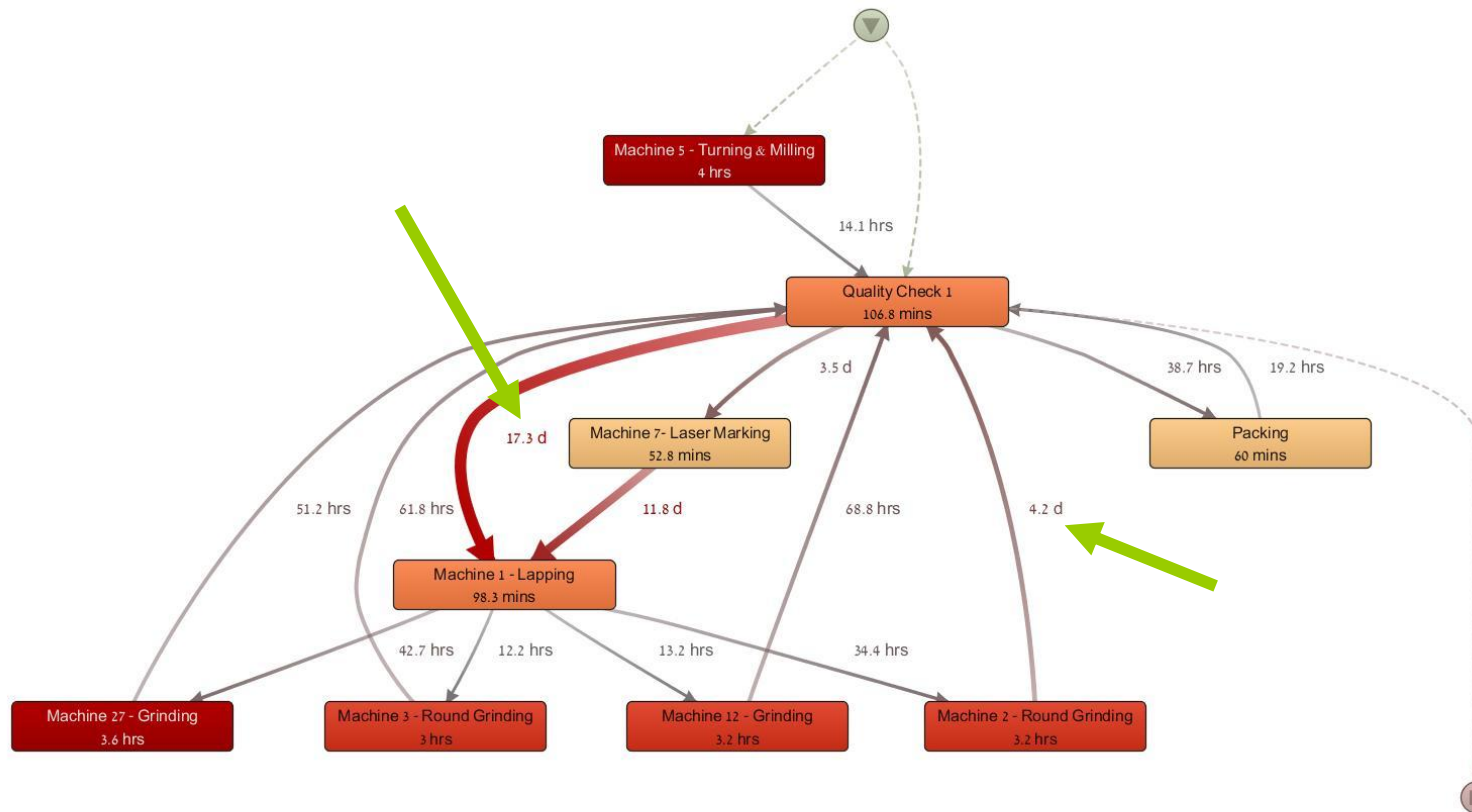
15 days, 9 hours

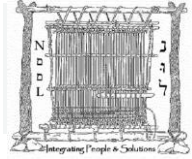
Maximum waiting time

Use cases where the mean waiting time is at least 2 days, 1 hour.

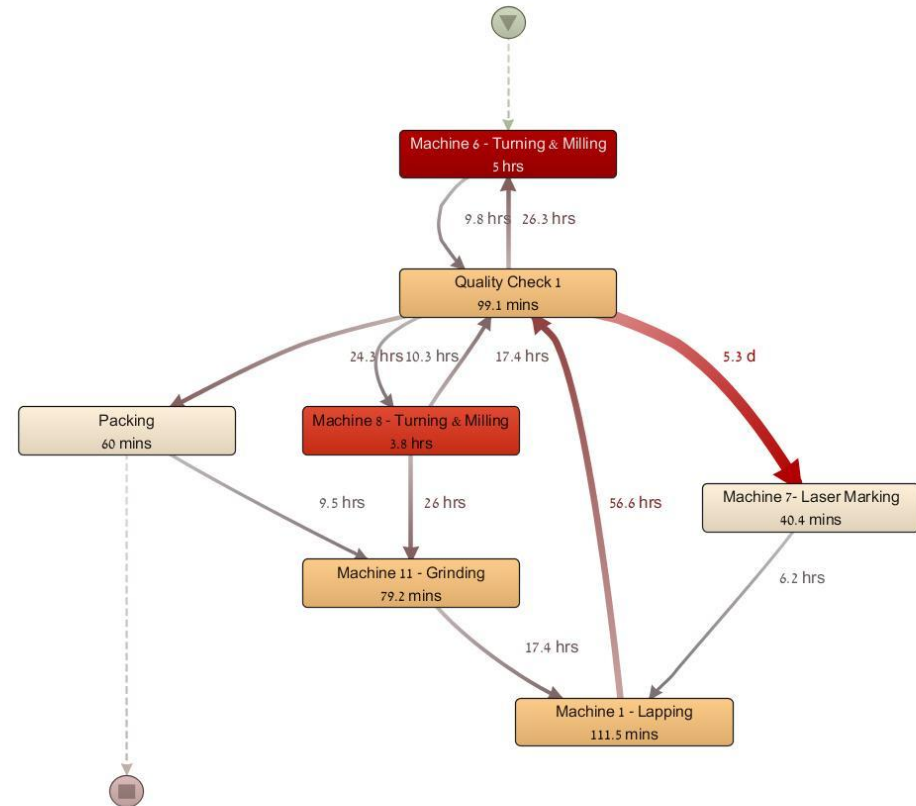


Mean Waiting Times in Work Cells

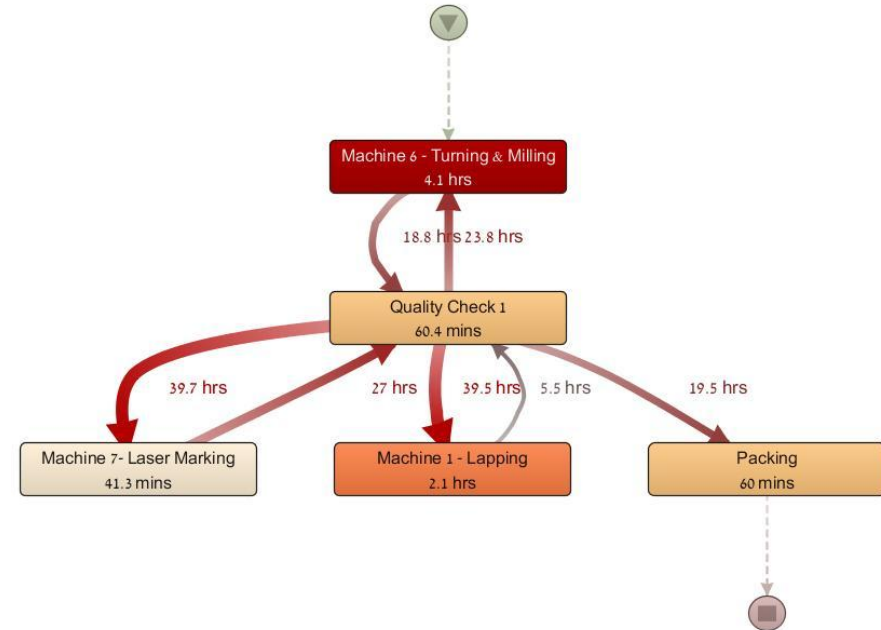




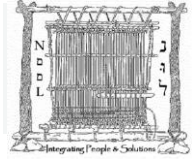
Comparing Fast and Slow Work orders of a Selected Part



Slow Work Orders

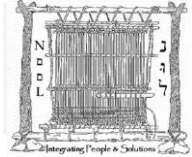


Fast Work Orders



Analysis of Breakdowns





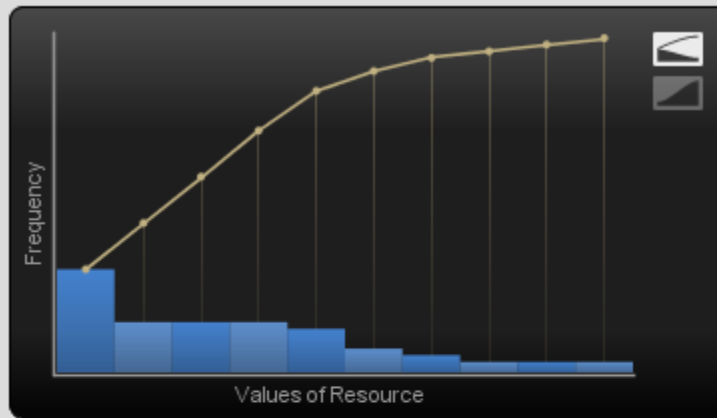
Statistics of the Work Cells in Question

Frequency

Mean duration

Duration range

Aggregate duration



Values 10

Minimal frequency 1

Mean frequency 5

Maximal frequency 15

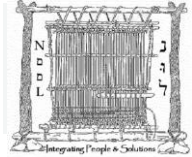
Frequency std. deviation 4.4

All values (10)

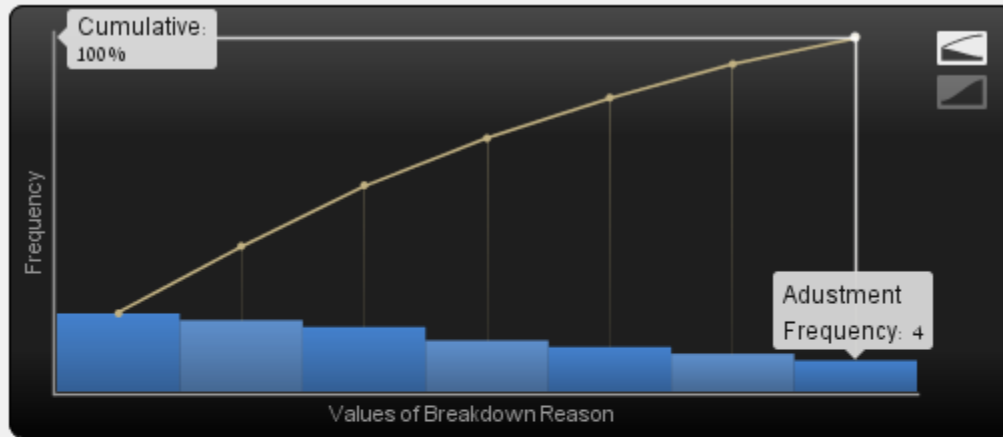
First in case (8)

Last in case (10)

Value	Frequency	Relative frequency	Mean duration	Duration range
Machine 8 - Turning & Milling	15	30 %	3 hours, 19 mins	14 hours, 15 mins
Machine 9 - Turning & Milling	7	14 %	3 hours, 1 min	8 hours, 5 mins
Machine 5 - Turning & Milling	7	14 %	2 hours, 23 mins	5 hours, 57 mins
Machine 6 - Turning & Milling	7	14 %	5 hours, 47 mins	17 hours, 7 mins
Machine 15 - Turning	6	12 %	1 hour, 46 mins	4 hours, 5 mins
Machine 4 - Turning & Milling	3	6 %	3 hours, 3 mins	7 hours, 54 mins
Machine 3 - Round Grinding	2	4 %	5 hours, 57 mins	3 hours, 26 mins
Machine 19 - Grinding	1	2 %	15 mins	0 millis
Machine 12 - Grinding	1	2 %	1 hour, 18 mins	0 millis
Machine 10 - Grinding	1	2 %	7 hours, 34 mins	0 millis



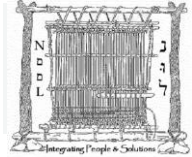
Statistics of the Breakdown Reasons



Values	7
Minimal frequency	4
Mean frequency	7.43
Maximal frequency	11
Frequency std. deviation	2.64

All values (7) First in case (7) Last in case (7)

Value	Frequency	Relative frequency	
Jam	11	21.15 %	
No Materials	10	19.23 %	
No Operator	9	17.31 %	
Cleaning	7	13.46 %	
No Electricity	6	11.54 %	
Breakdown	5	9.62 %	
Adustment	4	7.69 %	



Analysis by a Selected Breakdown Reason

Filter by: Breakdown Reason

Filtering n

This filter do not ha with one o

Work Order Qty

Part Desc.

Report Type

Qty Completed

Qty Rejected

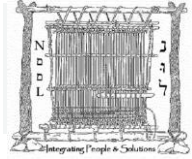
Qty for MRB

Rework

Breakdown Reason

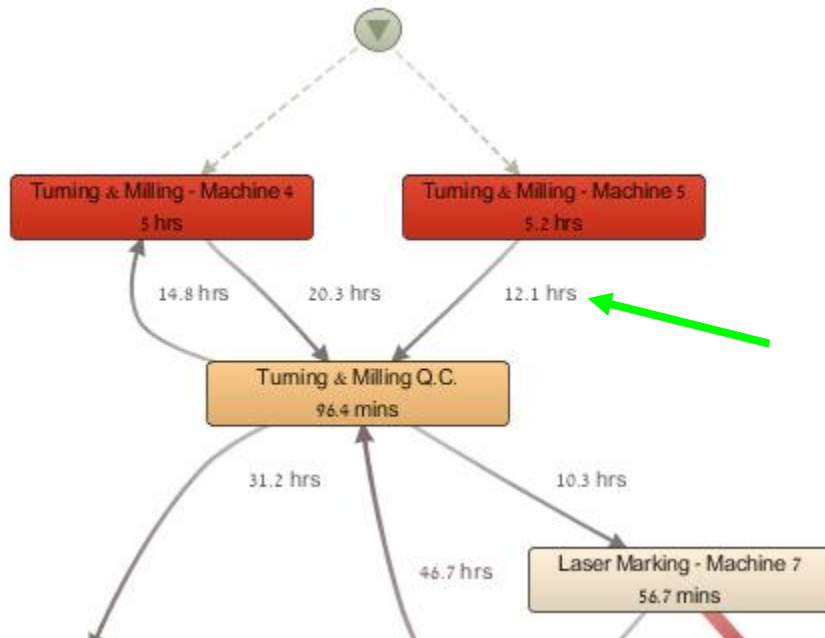
Event values: (1 of 8 selected)

<input type="checkbox"/>	
<input type="checkbox"/>	Adustment
<input type="checkbox"/>	Breakdown
<input type="checkbox"/>	Cleaning
<input type="checkbox"/>	Jam
<input type="checkbox"/>	No Electricity
<input checked="" type="checkbox"/>	No Materials
<input type="checkbox"/>	No Operator

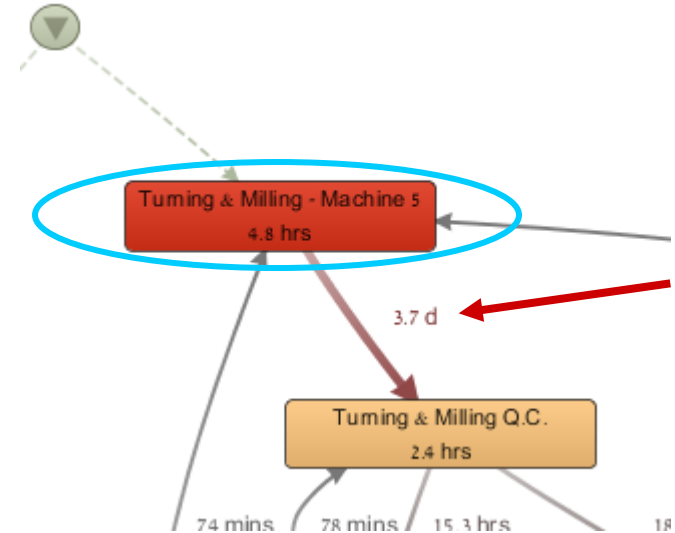


The Impact of a Breakdown on a Selected Part

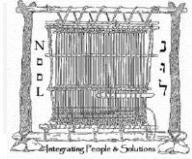
- The operation with the ellipse was reported as a breakdown
- The red arrow points at a delay in the process (compared to one indicated by the green arrow)



Without Breakdown

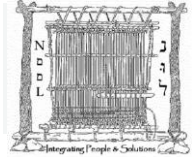


With Breakdown

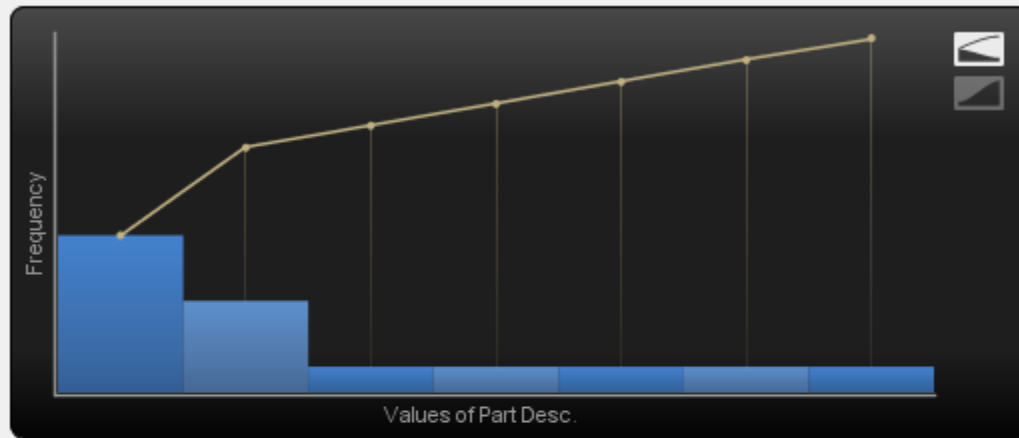


Analysis of Rejected & Rework





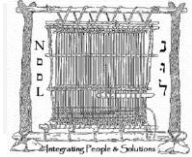
Statistics of Rejected Parts



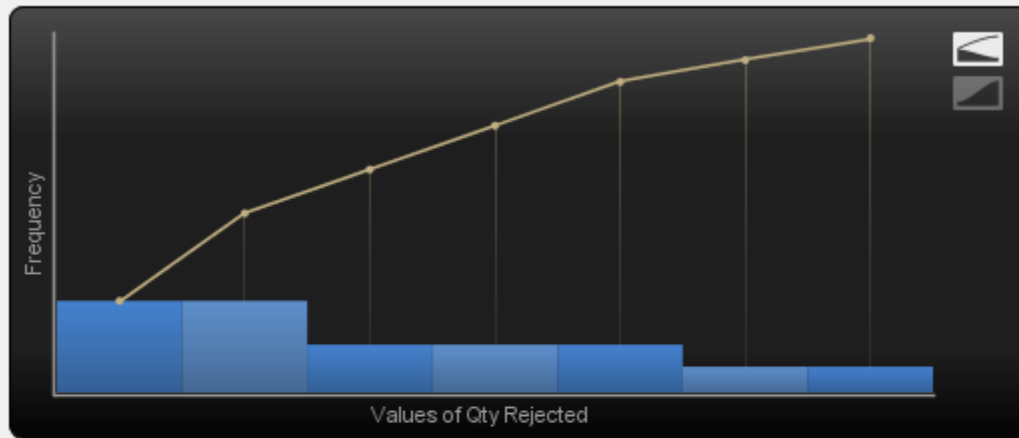
Values	7
Minimal frequency	1
Mean frequency	2.29
Maximal frequency	7
Frequency std. deviation	2.36

All values (7) First in case (3) Last in case (5)

Value	Frequency	Relative frequency	
Ballnut	7	43.75 %	
Cable Head	4	25 %	
Bearing	1	6.25 %	
Drill	1	6.25 %	
Electrical Contact	1	6.25 %	
Punch Holder	1	6.25 %	
Spur Gear	1	6.25 %	



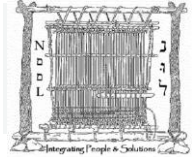
Statistics of Rejected Quantities



Values	7
Minimal frequency	1
Mean frequency	2.29
Maximal frequency	4
Frequency std. deviation	1.25

All values (7) First in case (5) Last in case (3)

Value	Frequency	Relative frequency	
1	4	25 %	
5	4	25 %	
3	2	12.5 %	
4	2	12.5 %	
2	2	12.5 %	
6	1	6.25 %	
8	1	6.25 %	



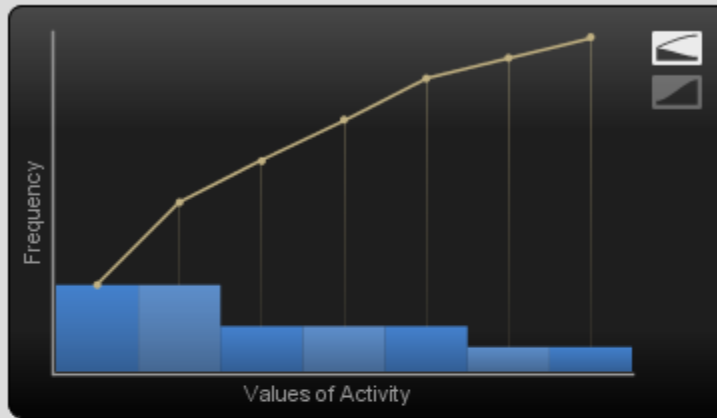
Statistics of the Operations Involved

Frequency

Mean duration

Duration range

Aggregate duration



Values 7

Minimal frequency 1

Mean frequency 2.29

Maximal frequency 4

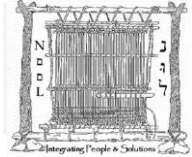
Frequency std. deviation 1.25

All values (7)

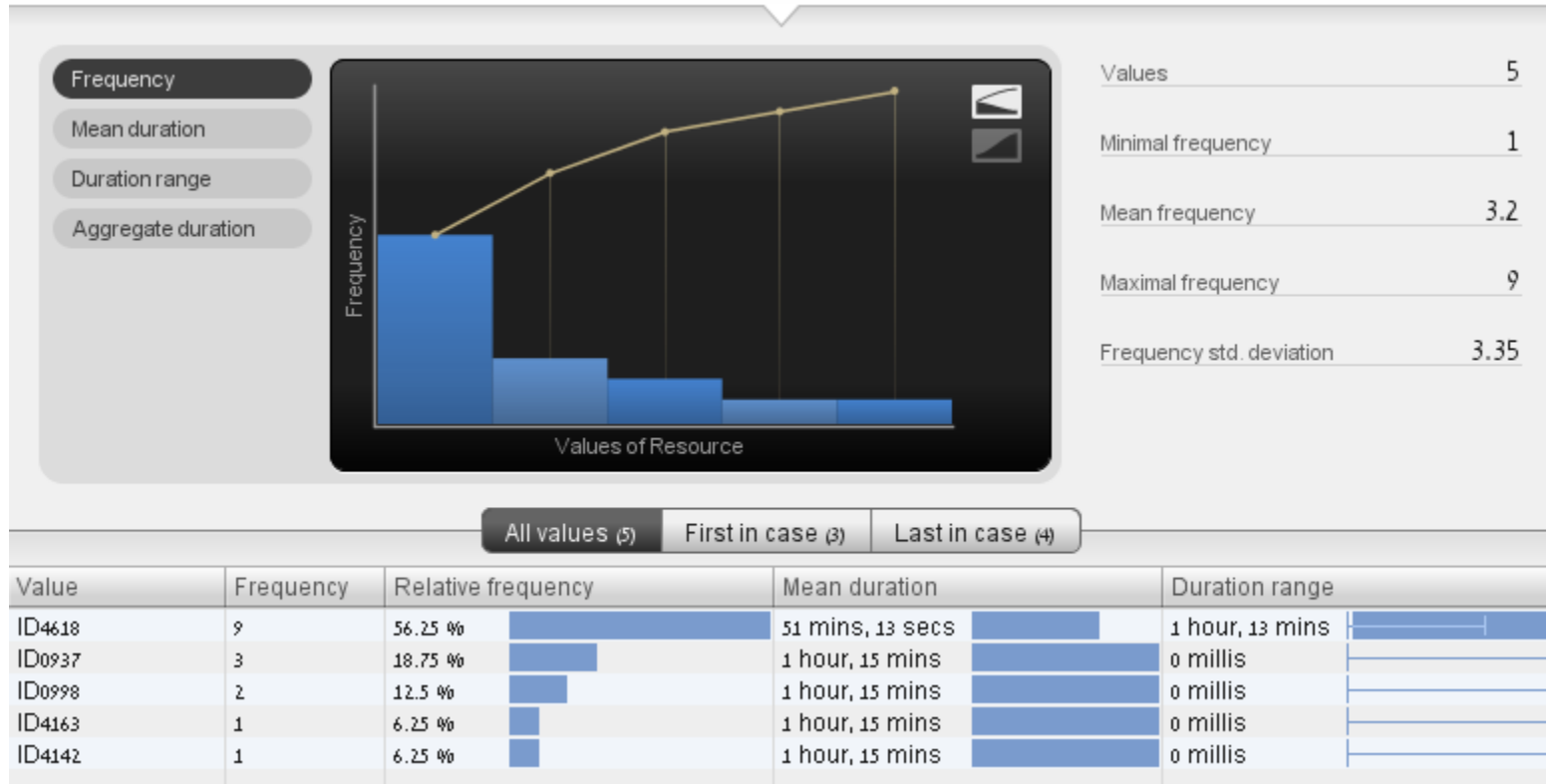
First in case (7)

Last in case (7)

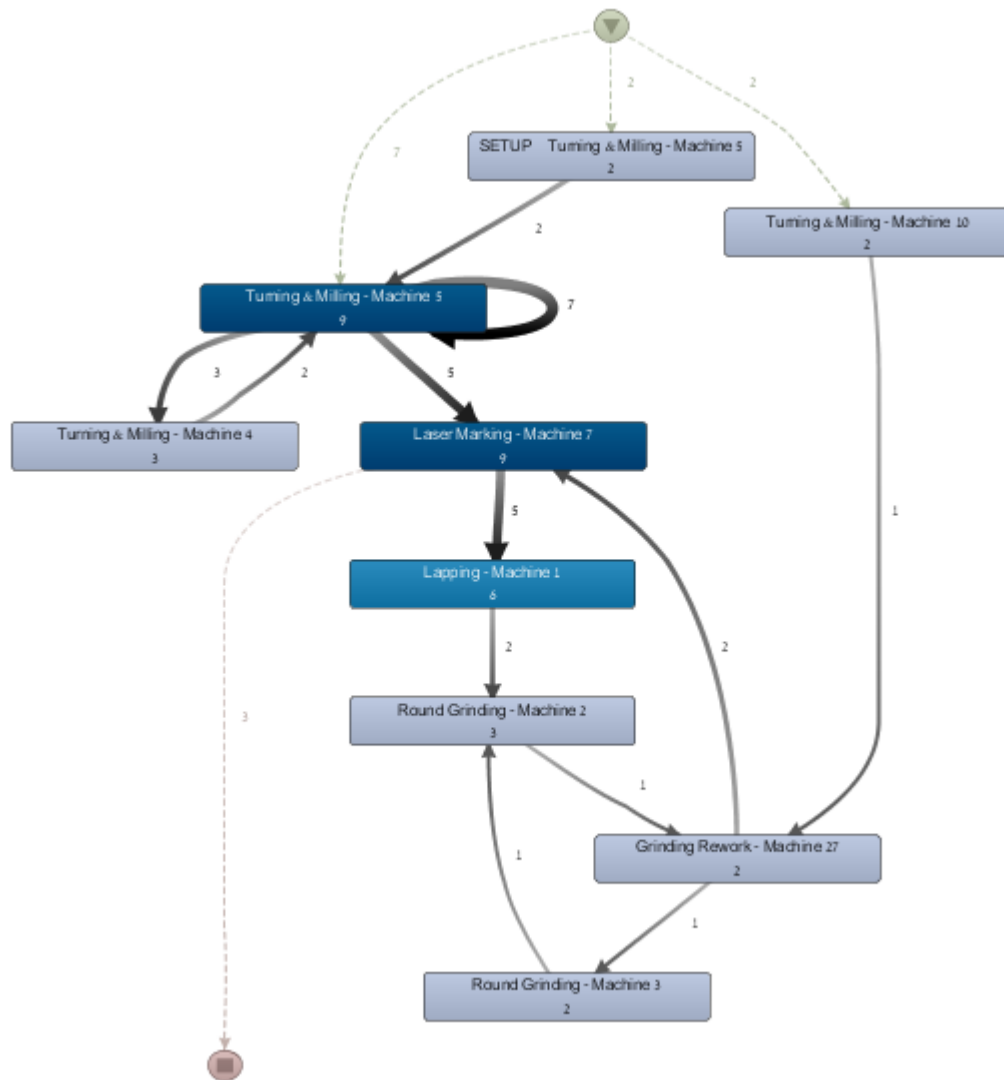
Value	Frequency	Relative frequency	Mean duration	Duration range
Laser Marking - Machine 7	4	25 %	1 hour, 15 mins	0 millis
Round Grinding - Machine 2	4	25 %	39 mins, 15 secs	1 hour, 13 mins
Lapping - Machine 1	2	12.5 %	1 hour, 15 mins	0 millis
Turning & Milling - Machine 10	2	12.5 %	39 mins, 30 secs	1 hour, 11 mins
Turning & Milling - Machine 6	2	12.5 %	1 hour, 15 mins	0 millis
Round Grinding - Machine 3	1	6.25 %	1 hour, 15 mins	0 millis
Flat Grinding - Machine 11	1	6.25 %	1 hour, 15 mins	0 millis



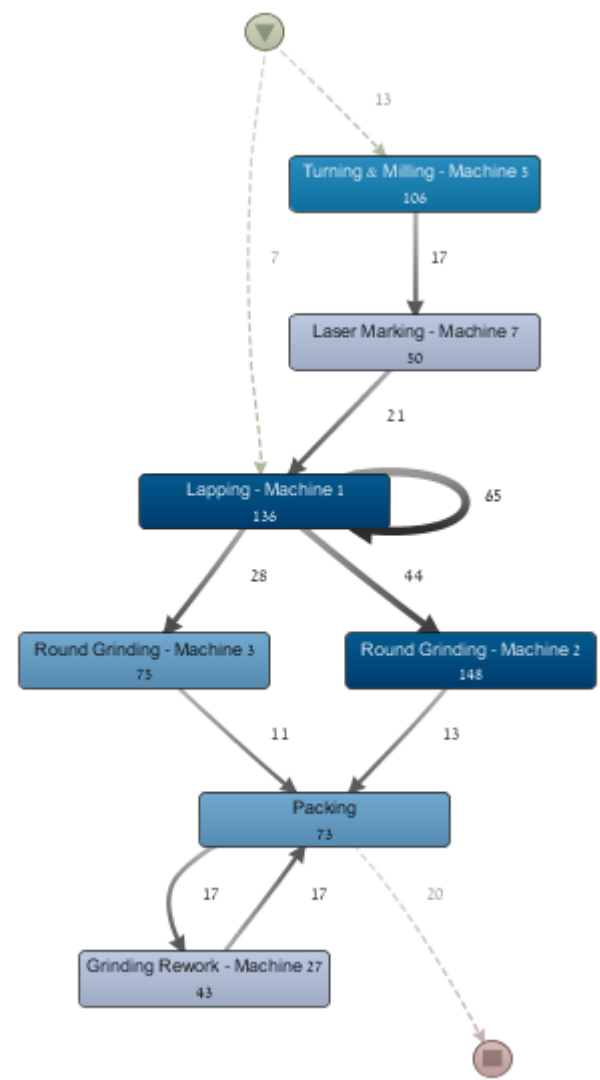
Statistics of the Workers Involved



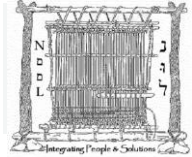
A Production Process of a Selected Part with & without Rejected



Without Rejected parts



With Rejected parts



Comparing Operations & Workers

With rejected parts

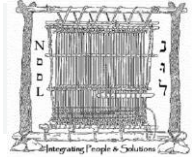
Value	Frequency	Relative frequency	Mean duration	Duration range
Lapping - Machine 1	2	50 %	1 hour, 15 mins	0 millis
Laser Marking - Machine 7	1	25 %	1 hour, 15 mins	0 millis
Turning & Milling - Machine...	1	25 %	1 hour, 15 mins	0 millis

Value	Frequency	Relative frequency
ID0937	1	25 %
ID4163	1	25 %
ID0998	1	25 %
ID4142	1	25 %

Without Rejected parts

Value	Frequency	Relative frequency	Mean duration	Duration range
Laser Marking - Machine 7	11	45.83 %	50 mins, 21 secs	2 hours, 38 mins
Lapping - Machine 1	11	45.83 %	2 hours, 13 mins	6 hours, 47 mins
Turning & Milling - Machine...	2	8.33 %	3 hours, 13 mins	3 hours, 56 mins

Value	Frequency	Relative frequency
ID0998	14	58.33 %
ID4882	4	16.67 %
ID4132	2	8.33 %
ID0937	2	8.33 %
ID4718	1	4.17 %
ID3846	1	4.17 %



Retrieving Work Orders with Rework

Filter by: Rework

Filtering mode:

☐ Keep selected

☒ Mandatory

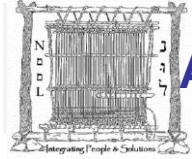
☐ Forbidden

This filter removes all cases that do not have at least one event with one of the selected values.

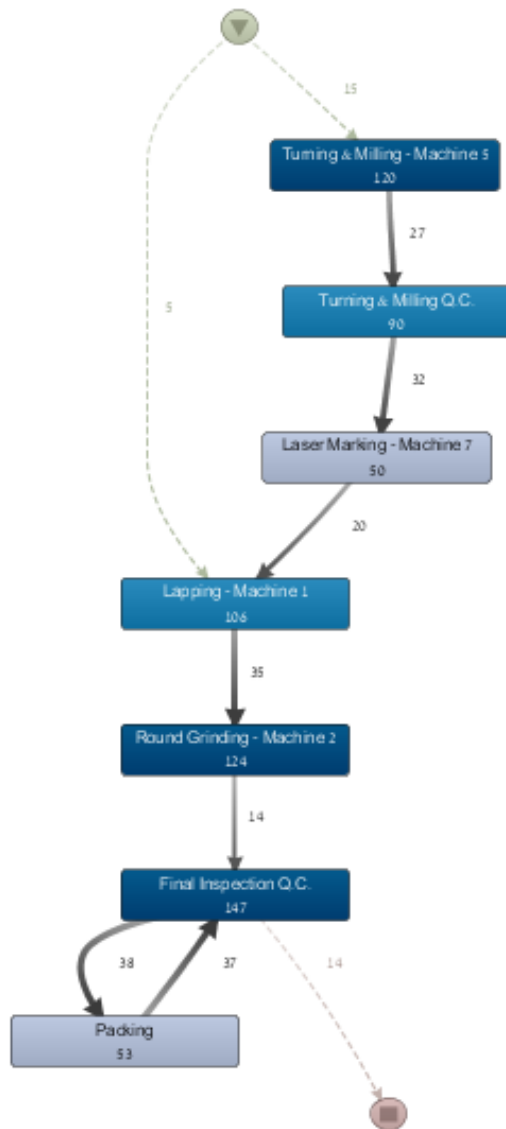
Event values: (1 of 2 selected)

✕

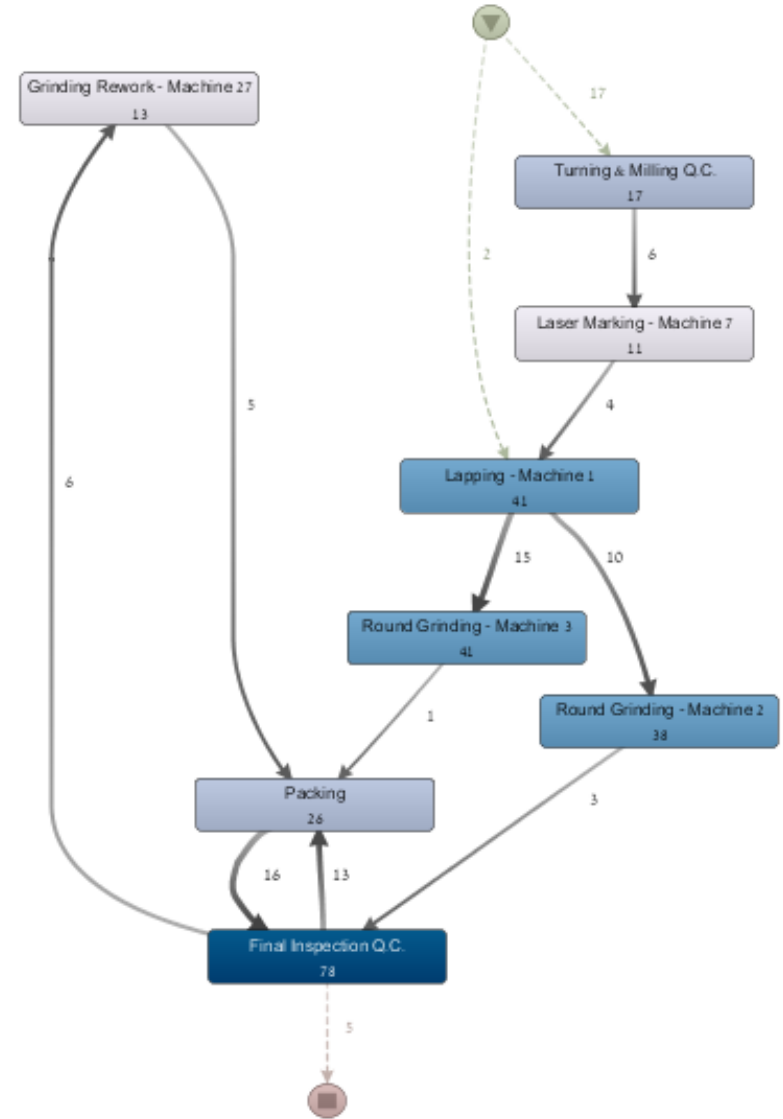
✓	Y
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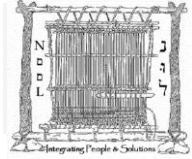
A Production Process of a Selected Part with & without Rework



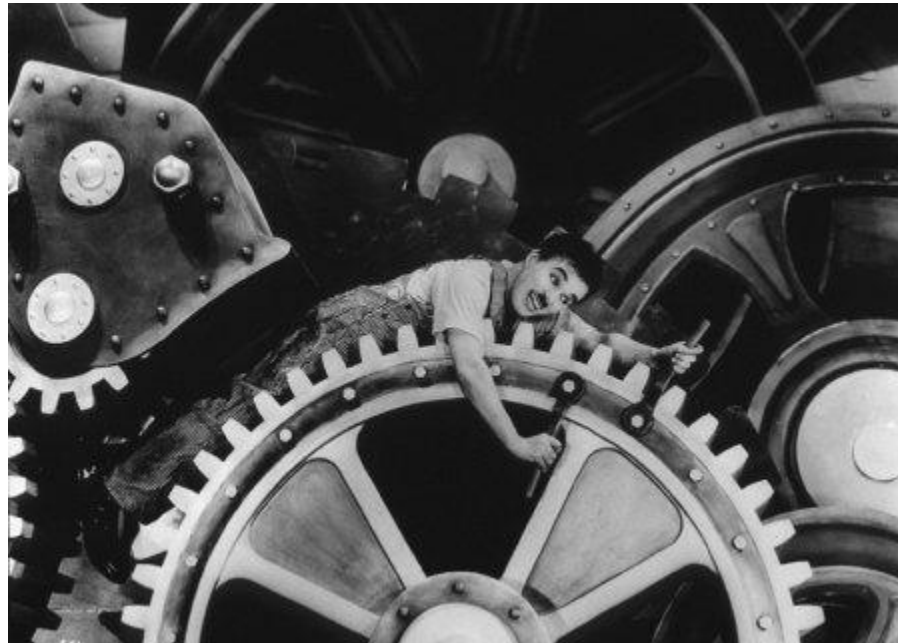
Without Rework

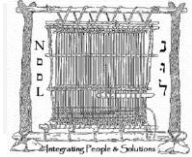


With Rework

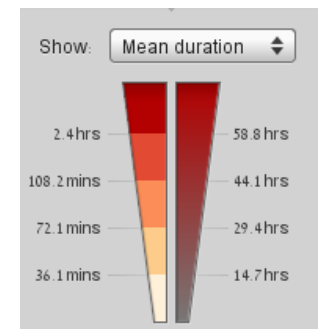
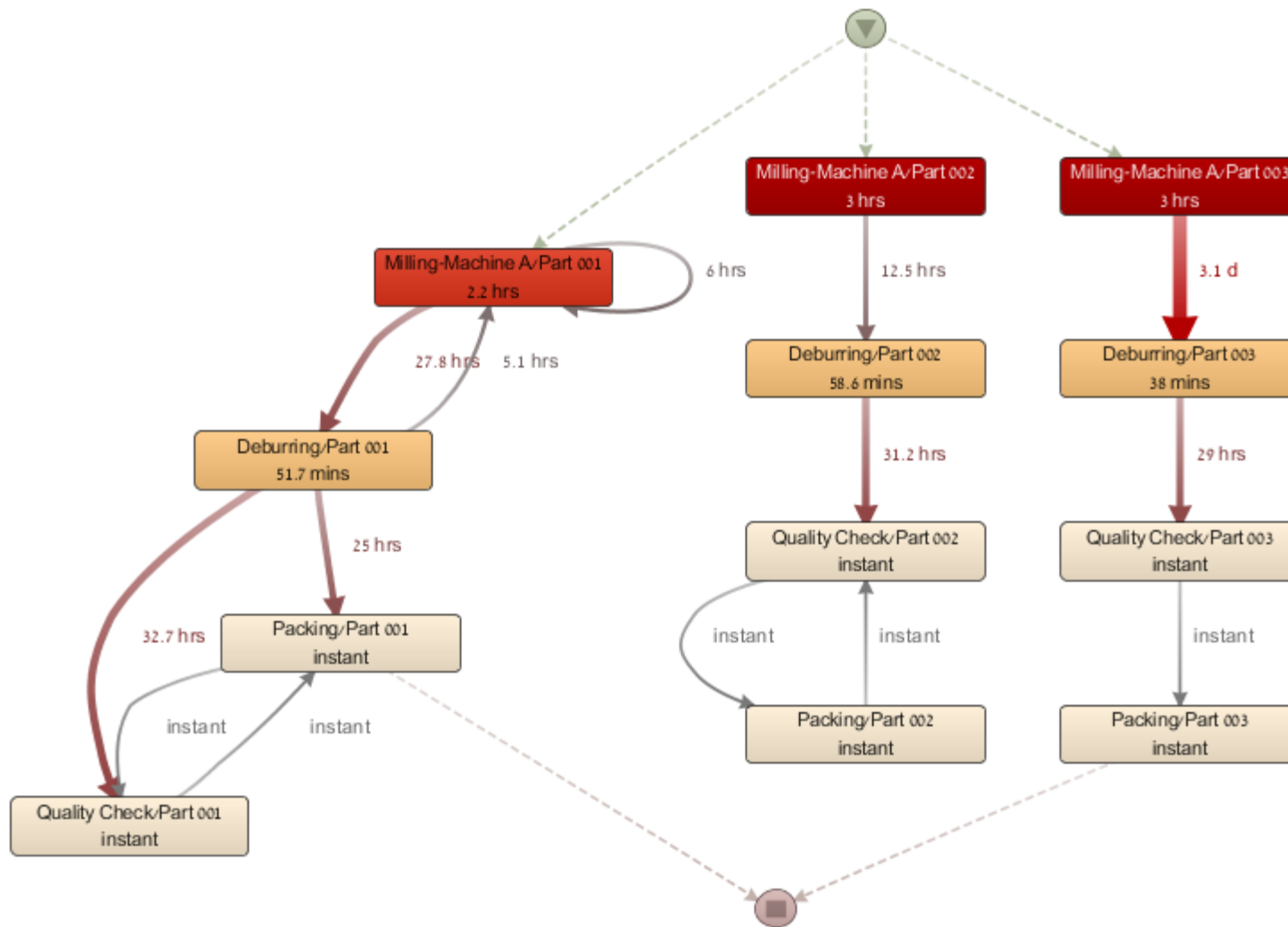


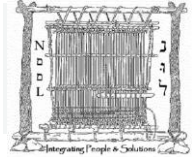
Additional Analysis





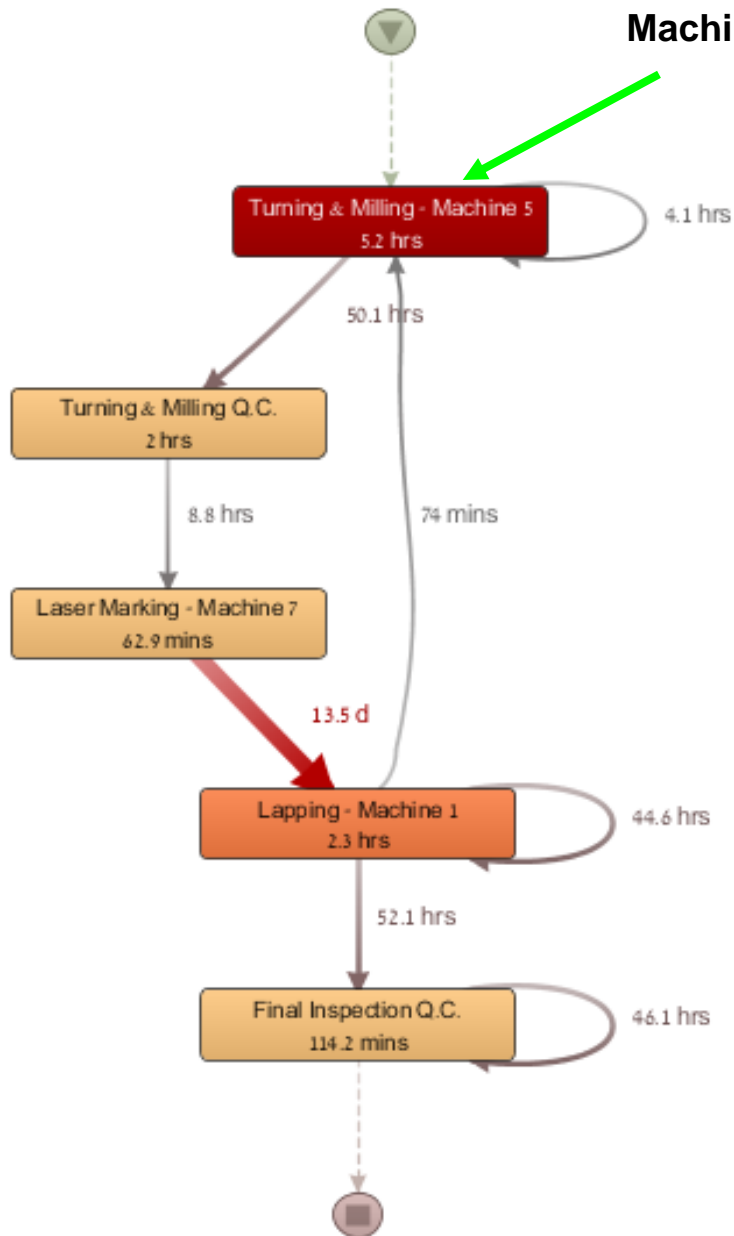
Comparing Production Processes of 3 Parts



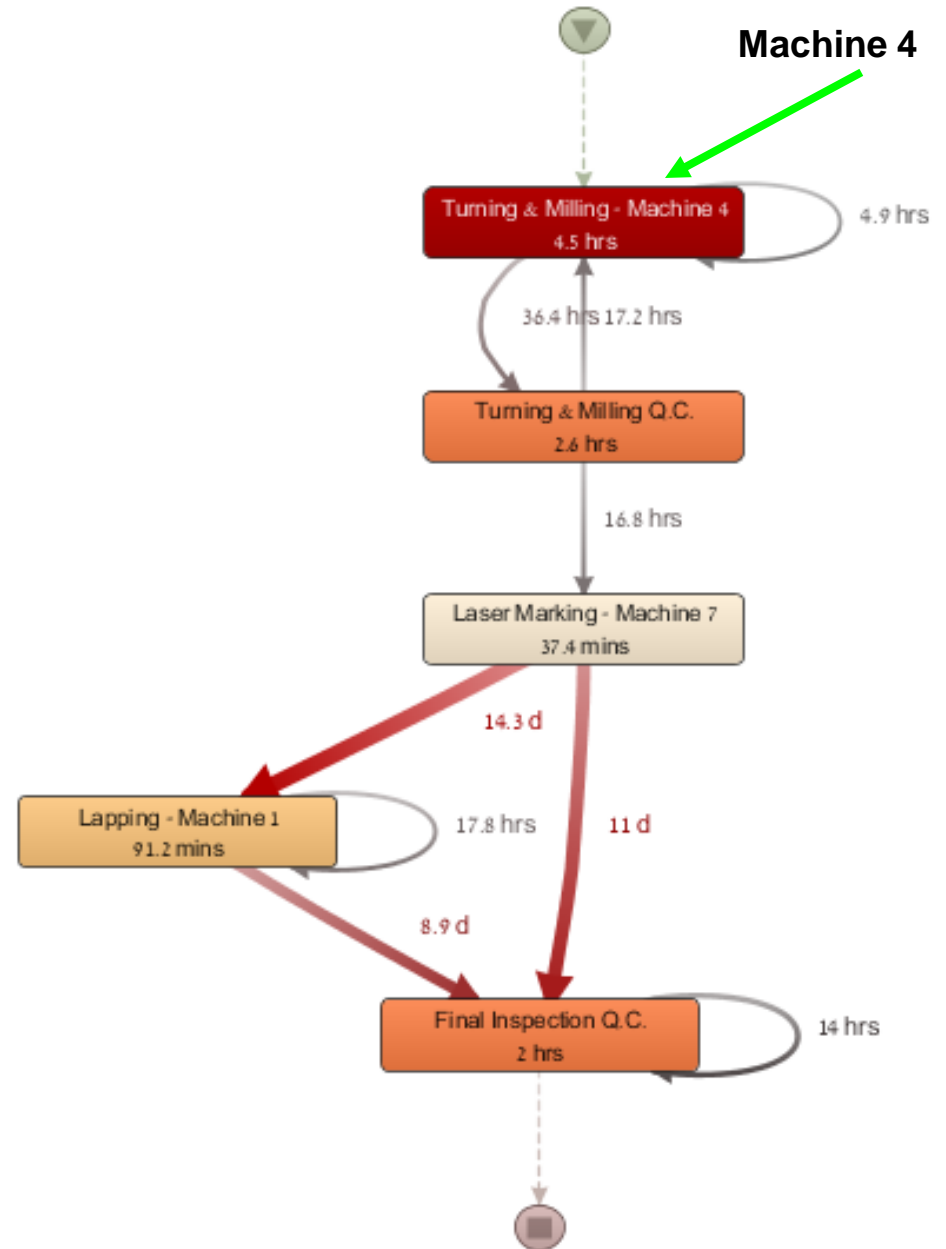


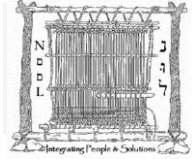
A Production Process of a Selected Part with Different Machine

Machine 5



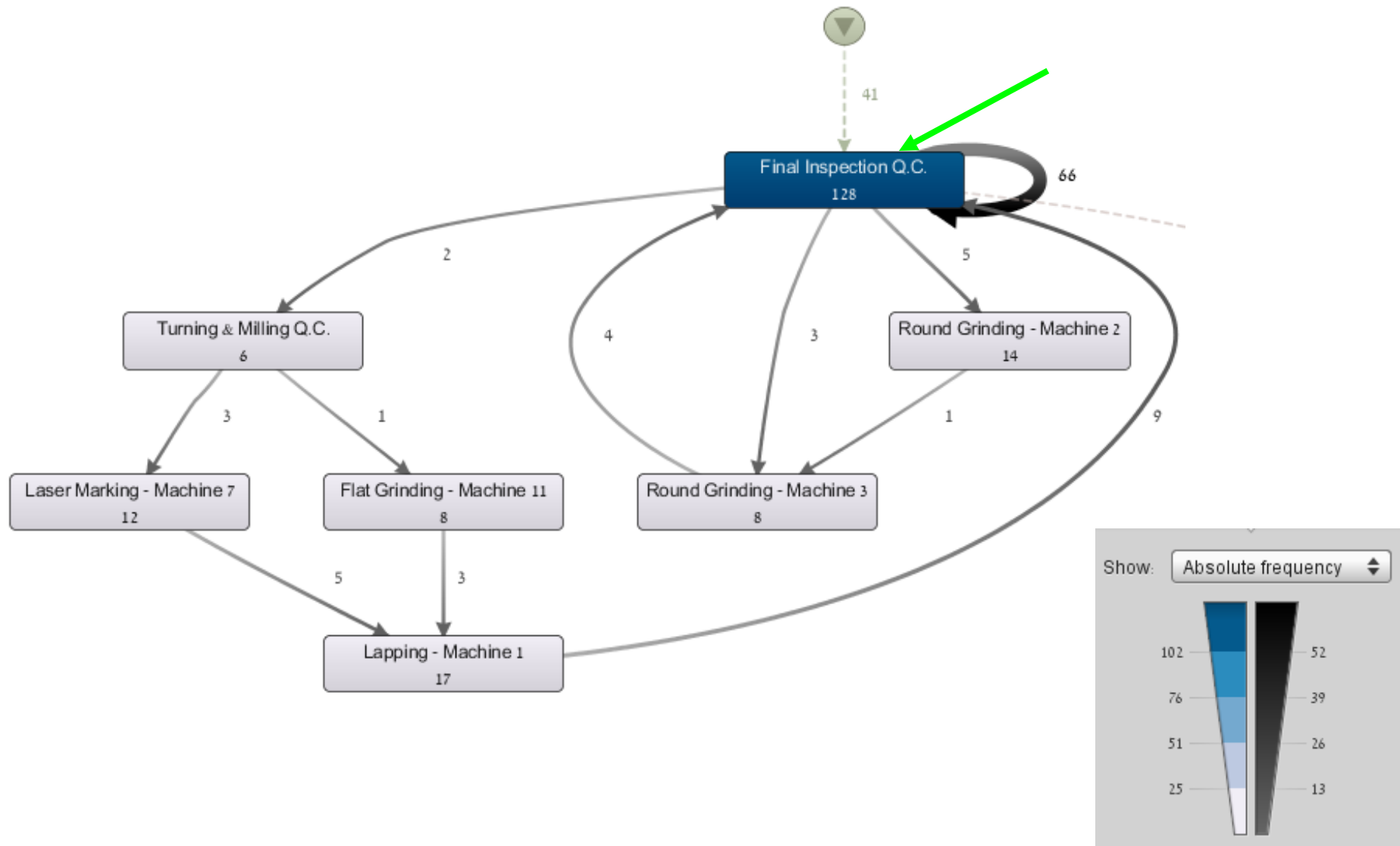
Machine 4

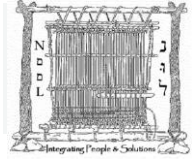




The Production Operations that Followed Final Inspection

- After trimming the process with the appropriate filter, we focus on the process starting from the final inspection.





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