

BPI Challenge 2020

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Abstract. The science of business process analysis is growing faster. Process Mining has become the most popular method for researching processes. Process Mining can help in the optimization task, the overall cost reduction of the company. So this year we are solving the BPI problem with a reimbursement process log offered by TU/e. The report deals with the detailed analysis of this data. When exploring data, we will apply methods of statistical data processing and methods for constructing process models. Let's consider separately two types of travel: domestic and international. Let's build and analyze process graphs and their differences. The main key performance indicators of this report are the following: throughput at each stage of the process, deviations in the reimbursement process, finding bottlenecks in the process of obtaining a travel permit, in the process of booking a trip. We will rely on the Celonis tool and the python libraries pm4py and pandas to build statistics and graphs of real processes.

Keywords: Business Process Intelligence · Process Mining · Process Model · Celonis

1 General information

The journal, which will be analyzed in this work, contains data for 2017 (two departments in total) and for 2018 full technical specifications / e. According to the description of the TU / e reimbursement process, prior authorization is not required for domestic travel, i.e. an employee can make these travels and subsequently claim reimbursement of costs, while international travel requires supervisor's authorization. The data is divided into travel permits and several types of requests, domestic declarations, international declarations.

1.1 General information about domestic declarations

Domestic Declarations: 10,500 cases, 56,437 events. A total of 10,500 national travel declarations were created. Payments were made on 10,043 declarations, 134 applications were generated by employees, but the approval process was not launched. Our cases take on average 7.00 days from first to last activity with the fastest case taking 1.00 days and the slowest case taking 368 days. We looked at cases where the application was rejected. 1,301 applications were rejected at various stages. One application can be rejected several times at different stages.

The Celonis tool allows you to quickly view cases with throughput time for analysis (see Fig. 1).

Throughput Time


Case ID	# Activities	Throughput Time 
declaration 101...	8	368.00 days
declaration 100...	10	344.00 days
declaration 126...	5	291.00 days
declaration 115...	4	286.00 days
declaration 981...	9	283.00 days
declaration 103...	11	266.00 days
declaration 956...	4	238.00 days
declaration 121...	9	230.00 days
declaration 101...	10	223.00 days
declaration 946...	4	202.00 days
declaration 134...	5	199.00 days
declaration 122...	6	192.00 days
declaration 95...	4	192.00 days

Fig. 1. Top 13 most slowest cases.

Throughput Time of Subprocess

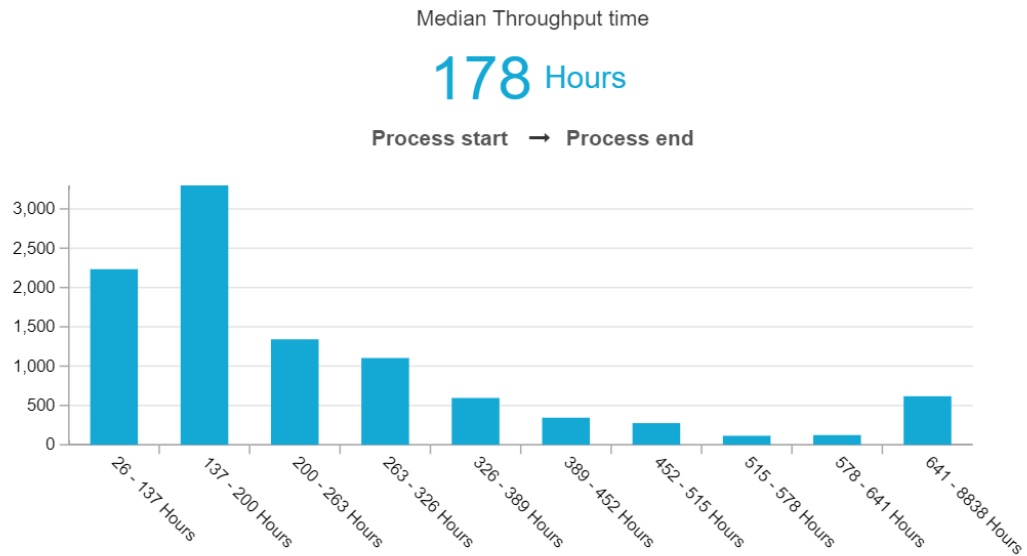


Fig. 2. Throughput time of processes.

Consider throughput time of processes in the diagram Fig. 2. On the diagram, we see that the largest number of cases go from the beginning of the process to the end of the process in the range of 137-200 hours or from 5 to 9 days. More than 500 applications are processed in more than 26 days. We have created a table that contains the throughput of each step in the domestic declaration process.

Table 1: Table that contains the throughput of each step in the international declaration process.

Course	target	Occurences	total through-put time in hours
Declaration SUBMITTED by EMPLOYEE	Declaration APPROVED by ADMINISTRATION	8202	0.00
Declaration APPROVED by ADMINISTRATION	Declaration APPROVED by BUDGET OWNER	2820	0.87
Declaration SUBMITTED by EMPLOYEE	Declaration APPROVED by PRE_APPROVER	685	0.00
Declaration APPROVED by ADMINISTRATION	Declaration APPROVED by SUPERVISOR	5133	0.87
Declaration APPROVED by BUDGET OWNER	Declaration APPROVED by SUPERVISOR	2784	1.91
Declaration APPROVED by PRE_APPROVER	Declaration APPROVED by SUPERVISOR	674	0.90
Declaration SUBMITTED by EMPLOYEE	Declaration APPROVED by SUPERVISOR	1536	0.00
Request Payment	Declaration APPROVED by SUPERVISOR	4	0.00
Declaration SUBMITTED by EMPLOYEE	Declaration FOR_APPROVAL by ADMINISTRATION	1	0.01
Declaration SUBMITTED by EMPLOYEE	Declaration FOR_APPROVAL by PRE_APPROVER	1	0.00
Declaration SUBMITTED by EMPLOYEE	Declaration FOR_APPROVAL by SUPERVISOR	1	0.00
Declaration SUBMITTED by EMPLOYEE	Declaration REJECTED by ADMINISTRATION	952	0.00
Declaration APPROVED by ADMINISTRATION	Declaration REJECTED by BUDGET OWNER	59	0.41

Declaration REJECTED by ADMINISTRATION	Declaration REJECTED by EMPLOYEE	928	0.92
Declaration REJECTED by BUDGET OWNER	Declaration REJECTED by EMPLOYEE	58	1.03
Declaration REJECTED by PRE_APPROVER	Declaration REJECTED by EMPLOYEE	85	0.92
Declaration REJECTED by SUPERVISOR	Declaration REJECTED by EMPLOYEE	286	1.05
Declaration SUBMITTED by EMPLOYEE	Declaration REJECTED by EMPLOYEE	7	0.00
Payment Handled	Declaration REJECTED by EMPLOYEE	1	1.63
Declaration FINAL_APPROVED by SUPERVISOR	Declaration REJECTED by MISSING	86	3.07
Declaration FOR_APPROVAL by PRE_APPROVER	Declaration REJECTED by MISSING	1	4.09
Declaration FOR_APPROVAL by SUPERVISOR	Declaration REJECTED by MISSING	1	0.79
Request Payment	Declaration REJECTED by MISSING	3	26.77
Declaration SUBMITTED by EMPLOYEE	Declaration REJECTED by PRE_APPROVER	86	0.00
Declaration APPROVED by ADMINISTRATION	Declaration REJECTED by SUPERVISOR	190	0.95
Declaration APPROVED by BUDGET OWNER	Declaration REJECTED by SUPERVISOR	32	4.04
Declaration APPROVED by PRE_APPROVER	Declaration REJECTED by SUPERVISOR	11	2.09
Declaration SUBMITTED by EMPLOYEE	Declaration REJECTED by SUPERVISOR	60	0.00
Declaration FOR_APPROVAL by ADMINISTRATION	Declaration SUBMITTED by EMPLOYEE	1	1.02
Declaration REJECTED by ADMINISTRATION	Declaration SUBMITTED by EMPLOYEE	19	0.95
Declaration REJECTED by BUDGET OWNER	Declaration SUBMITTED by EMPLOYEE	1	6.09
Declaration REJECTED by EMPLOYEE	Declaration SUBMITTED by EMPLOYEE	1081	0.20
Declaration REJECTED by MISSING	Declaration SUBMITTED by EMPLOYEE	61	0.42
Declaration REJECTED by PRE_APPROVER	Declaration SUBMITTED by EMPLOYEE	1	0.06

Declaration REJECTED by SUPERVISOR	Declaration SUBMITTED by EMPLOYEE	2	2.75
Declaration FINAL_APPROVED by SUPERVISOR	Payment Handled	11	48.25
Request Payment	Payment Handled	1033	3.24
Declaration APPROVED by BUDGET OWNER	Request Payment	4	1.98
Declaration FINAL_APPROVED by SUPERVISOR	Request Payment	1034	1.14
Declaration REJECTED by SUPERVISOR	Request Payment	1	6.92
Declaration SAVED by EMPLOYEE	Request Payment	1	17.03

Build a graph of the process of creating and considering domestic declaration (Fig. 3).

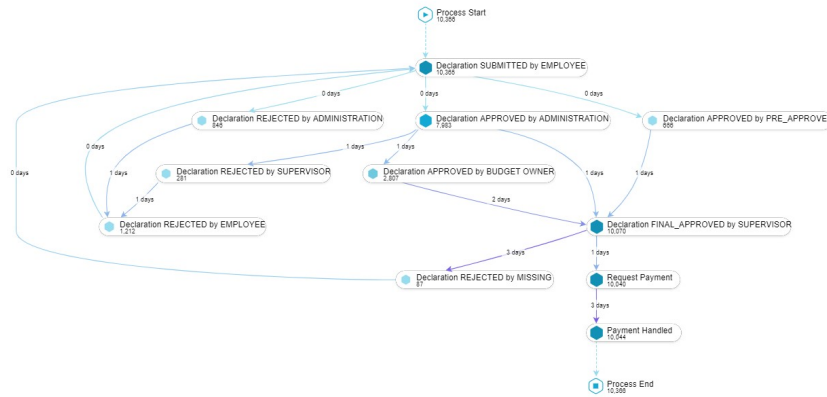


Fig. 3. Domestic declaration median graph.

We will find how many corrections were made to the declaration. In 10% of cases, the event was executed more than once. Refinement means that the same action is performed more than once in the same case.

Based on statistical calculations, we have found the ideal process path (Fig. 4). 44.55% of cases flow via happy path or 4618 of 10366 cases. Activities that occur often, but are not necessarily part of optimal process (Fig. 5).

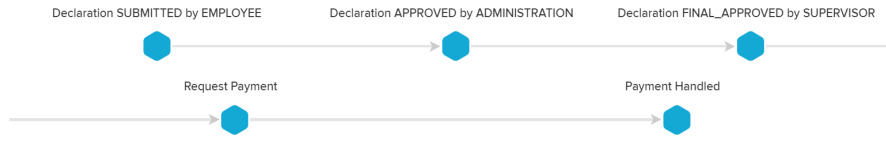


Fig. 4. Algorithmic happy path.

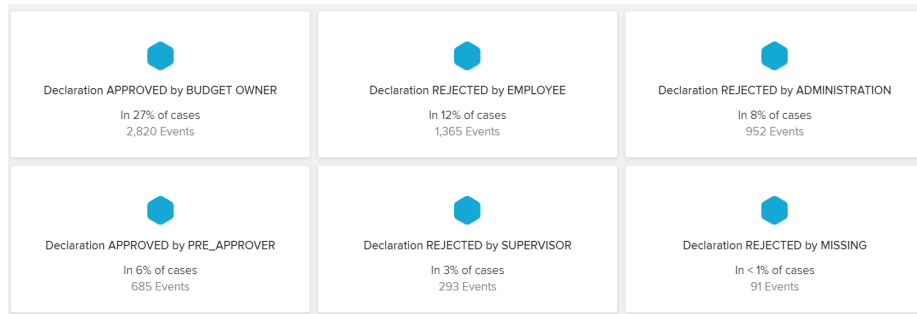


Fig. 5. Other frequent activities.

Highlight the process bottleneck in the Celonis tool (Fig. 6). We believe that to optimize the process, it is necessary to consider options for transition from the state Declaration APPROVED BY THE BUDGET OWNER in the state Declaration FINAL_APPROVED by SUPERVISOR.

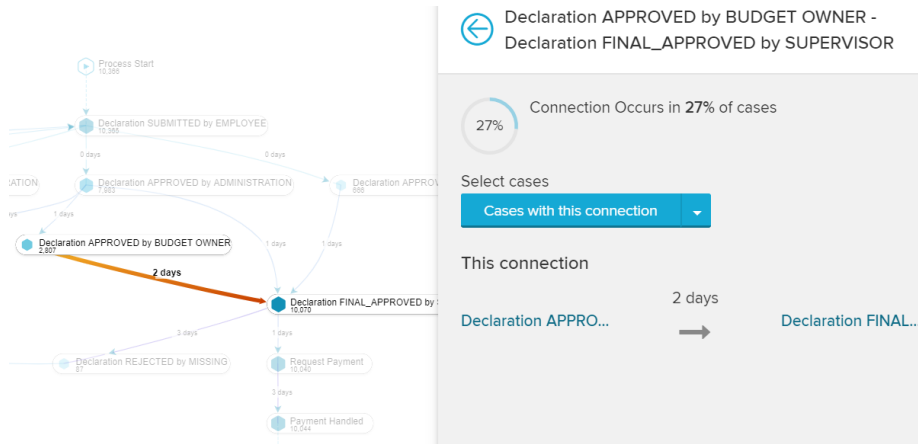


Fig. 6. Process bottleneck.

1.2 General information about international declarations

International Declarations: 6,449 cases, 72151 events. Our cases take on average 66.00 days from first to last activity with the fastest case taking 6.00 days and the slowest case taking 742 days.

The Celonis tool allows you to quickly view cases with throughput time for analysis(see Fig. 7).

Throughput Time


Case ID	# Activities	Throughput Time 
declaration 61184	16	742.00 days
declaration 7483	10	463.00 days
declaration 143...	12	459.00 days
declaration 143...	6	459.00 days
declaration 143...	6	459.00 days
declaration 143...	6	458.00 days
declaration 143...	3	458.00 days
declaration 143...	6	458.00 days
declaration 143...	6	458.00 days
declaration 143...	13	458.00 days
declaration 143...	6	457.00 days
declaration 143...	6	456.00 days
declaration 143...	6	456.00 days
declaration 143...	6	455.00 days
declaration 143...	6	455.00 days
declaration 143...	6	452.00 days

Fig. 7. Top 13 most slowest cases.

Consider throughput time of processes in the diagram Fig. 8. On the diagram, we see that the largest number of cases go from the beginning of the process to the end of the process in the range of 161-964 hours or from 6 to 43 days. More than 300 applications are processed in more than 223 days. We have created a table that contains the throughput of each step in the international declaration process.

Table 2: Table that contains the throughput of each step in the international declaration process.

SourceABC	TargetABC	Occurences123	Total through-put time in hours0.1f
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Declaration SUBMITTED by EMPLOYEE	Declaration APPROVED by ADMINISTRATION	4952	0.00
End trip	Declaration APPROVED by ADMINISTRATION	79	3.48
Start trip	Declaration APPROVED by ADMINISTRATION	6	4.89
Declaration APPROVED by ADMINISTRATION	Declaration APPROVED by BUDGET OWNER	1815	1.08
End trip	Declaration APPROVED by BUDGET OWNER	18	3.47
Start trip	Declaration APPROVED by BUDGET OWNER	1	2.45
Declaration SUBMITTED by EMPLOYEE	Declaration APPROVED by PRE _A PPROVER	604	0.00
End trip	Declaration APPROVED by PRE _A PPROVER	7	4.89
Permit	Declaration APPROVED by PRE _A PPROVED by SUPERVISOR	1	34.72
Declaration APPROVED by ADMINISTRATION	Declaration APPROVED by SUPERVISOR	103	1.09
Declaration APPROVED by BUDGET OWNER	Declaration APPROVED by SUPERVISOR	50	1.98
Declaration APPROVED by PRE _A PPROVER	Declaration APPROVED by SUPERVISOR	11	0.97
Declaration FINAL _A PPROVED by DIRECTOR	Declaration APPROVED by SUPERVISOR	3	0.00
Declaration SUBMITTED by EMPLOYEE	Declaration APPROVED by SUPERVISOR	88	0.01
End trip	Declaration APPROVED by SUPERVISOR	1	13.41
Declaration APPROVED by BUDGET OWNER	Declaration FINAL _A PPROVED by DIRECTOR	1	3.16
Declaration APPROVED by PRE _A PPROVER	Declaration FINAL _A PPROVED by DIRECTOR	1	0.06
Declaration APPROVED by SUPERVISOR	Declaration FINAL _A PPROVED by DIRECTOR	249	1.16
Declaration SUBMITTED by EMPLOYEE	Declaration FINAL _A PPROVED by DIRECTOR	1	11.11
Declaration APPROVED by ADMINISTRATION	Declaration FINAL _A PPROVED by SUPERVISOR	2959	1.11
Declaration APPROVED by BUDGET OWNER	Declaration FINAL _A PPROVED by SUPERVISOR	1745	2.00
Declaration APPROVED by PRE _A PPROVER	Declaration FINAL _A PPROVED by SUPERVISOR	582	0.92

Declaration SUBMITTED by EMPLOYEE	Declaration FINAL _A PPROVEDbySUPERVISOR	702	0.00
End trip	Declaration FINAL _A PPROVEDbySUPERVISOR	43	3.44
Permit REJECTED by MISSING	Declaration FINAL _A PPROVEDbySUPERVISOR	1	0.08
Request Payment	Declaration FINAL _A PPROVEDbySUPERVISOR	1	0.00
Start trip	Declaration FINAL _A PPROVEDbySUPERVISOR	6	1.46
Declaration SUBMITTED by EMPLOYEE	Declaration REJECTED by ADMINISTRATION	1517	0.01
End trip	Declaration REJECTED by ADMINISTRATION	29	3.41
Start trip	Declaration REJECTED by ADMINISTRATION	3	6.81
Declaration APPROVED by ADMINISTRATION	Declaration REJECTED by BUDGET OWNER	40	1.47
Declaration APPROVED by SUPERVISOR	Declaration REJECTED by DIRECTOR	4	5.95
Declaration REJECTED by ADMINISTRATION	Declaration REJECTED by EMPLOYEE	1510	1.81
Declaration REJECTED by BUDGET OWNER	Declaration REJECTED by EMPLOYEE	39	1.29
Declaration REJECTED by DIRECTOR	Declaration REJECTED by EMPLOYEE	4	13.01
Declaration REJECTED by PRE _A PPROVER	Declaration REJECTED by EMPLOYEE	82	0.81
Declaration REJECTED by SUPERVISOR	Declaration REJECTED by EMPLOYEE	120	1.97
Declaration SUBMITTED by EMPLOYEE	Declaration REJECTED by EMPLOYEE	5	0.00
End trip	Declaration REJECTED by EMPLOYEE	16	3.54
Permit REJECTED by MISSING	Declaration REJECTED by EMPLOYEE	1	0.05
Start trip	Declaration REJECTED by EMPLOYEE	3	2.36
Declaration FINAL _A PPROVEDbyDIRECTOR	Declaration REJECTED by MISSING	9	2.19
Declaration FINAL _A PPROVEDbySUPERVISOR	Declaration REJECTED by MISSING	93	2.75
End trip	Declaration REJECTED by MISSING	1	5.66

Declaration SUBMITTED by EMPLOYEE	Declaration REJECTED by 81 PRE _A PPROVER	0.01
End trip	Declaration REJECTED by 2 PRE _A PPROVER	6.45
Start trip	Declaration REJECTED by 1 PRE _A PPROVER	3.93
Declaration APPROVED by ADMINISTRATION	Declaration REJECTED by SU-71 PERVISOR	2.77
Declaration APPROVED by BUDGET OWNER	Declaration REJECTED by SU-26 PERVISOR	3.99
Declaration APPROVED by PRE _A PPROVER	Declaration REJECTED by SU-15 PERVISOR	6.59
Declaration SUBMITTED by EMPLOYEE	Declaration REJECTED by SU-13 PERVISOR	0.01
Start trip	Declaration REJECTED by SU-1 PERVISOR	3.83
Declaration REJECTED by EMPLOYEE	Declaration SAVED by EM-1 EMPLOYEE	0.05
End trip	Declaration SAVED by EM-36 EMPLOYEE	12.50
Permit FINAL _A PPROVED by DIRECTOR	Declaration SAVED by EM-4 EMPLOYEE	13.32
Permit FINAL _A PPROVED by SUPERVISOR	Declaration SAVED by EM-11 EMPLOYEE	14.04
Send Reminder	Declaration SAVED by EM-14 EMPLOYEE	3.29
Start trip	Declaration SAVED by EM-1 EMPLOYEE	2.10
Declaration REJECTED by ADMINISTRATION	Declaration SUBMITTED by 24 EMPLOYEE	1.83
Declaration REJECTED by EMPLOYEE	Declaration SUBMITTED by 1601 EMPLOYEE	0.12
Declaration REJECTED by MISSING	Declaration SUBMITTED by 86 EMPLOYEE	0.83
Declaration REJECTED by SUPERVISOR	Declaration SUBMITTED by 3 EMPLOYEE	1.13
End trip	Declaration SUBMITTED by 4484 EMPLOYEE	5.67
Permit FINAL _A PPROVED by DIRECTOR	Declaration SUBMITTED by 95 EMPLOYEE	26.33
Permit FINAL _A PPROVED by SUPERVISOR	Declaration SUBMITTED by 776 EMPLOYEE	6.20
Send Reminder	Declaration SUBMITTED by 378 EMPLOYEE	8.22

Start trip	Declaration SUBMITTED by EMPLOYEE	245	5.37
Declaration APPROVED by ADMINISTRATION	End trip	43	0.41
Declaration APPROVED by BUDGET OWNER	End trip	8	1.38
Declaration APPROVED by PREAPPROVER	End trip	2	2.40
Declaration FINALAPPROVEDbySUPERVISOR	End trip	10	1.39
Declaration REJECTED by ADMINISTRATION	End trip	9	0.33
Declaration REJECTED by BUDGET OWNER	End trip	1	1.46
Declaration REJECTED by EMPLOYEE	End trip	10	41.64
Declaration REJECTED by MISSING	End trip	1	47.57
Declaration REJECTED by PREAPPROVER	End trip	1	0.07
Declaration REJECTED by SUPERVISOR	End trip	2	0.51
Declaration SAVED by EMPLOYEE	End trip	2	270.37
Declaration SUBMITTED by EMPLOYEE	End trip	59	1.62
Payment Handled	End trip	124	87.27
Permit APPROVED by ADMINISTRATION	End trip	59	0.55
Permit APPROVED by BUDGET OWNER	End trip	46	1.53
Permit APPROVED by PREAPPROVER	End trip	8	1.30
Permit APPROVED by SUPERVISOR	End trip	2	2.49
Permit FINALAPPROVEDbyDIRECTOR	End trip	38	5.59
Permit FINALAPPROVEDbySUPERVISOR	End trip	392	2.52
Permit REJECTED by EMPLOYEE	End trip	2	13.55
Permit REJECTED by SUPERVISOR	End trip	2	4.57

Permit SUBMITTED by EMPLOYEE	End trip	1	10.10
Request Payment	End trip	13	1.56
Start trip	End trip	5559	4.00
Declaration FINALAPPROVEDbySUPERVISOR	Payment Handled	6	131.40
End trip	Payment Handled	15	1.73
Permit REJECTED by MISSING	Payment Handled	10	3.28
Request Payment	Payment Handled	6148	3.22
Start trip	Payment Handled	8	2.73
End trip	Permit APPROVED by ADMINISTRATION	7	6.54
Permit SUBMITTED by EMPLOYEE	Permit APPROVED by ADMINISTRATION	4829	0.00
Start trip	Permit APPROVED by ADMINISTRATION	3	0.56
End trip	Permit APPROVED by BUDGET OWNER	24	2.66

Build a graph of the process of creating and considering international declaration (Fig. 9).

We will find how many corrections were made to the declaration. For 25% of our cases an event has been executed more than once. Refinement means that the same action is performed more than once in the same case.

Based on statistical calculations, we have found the ideal process path (Fig. 10). 44.55% of cases flow via happy path or 1321 of 6449 cases. Activities that occur often, but are not necessarily part of optimal process (Fig. 11).

We found that 11% of Applications start with a trip. After the trip, permits are agreed and the payment of travel allowances (Fig. 12).

6% of applications start with payments (Declaration SUBMITTED by EMPLOYEE). In 6% of cases, 77 days pass between payment (Payment handled) and the beginning of a business trip (start trip).

In 8% of cases, 43 days pass from the agreement with the Director (Permit FINALAPPROVED by DIRECTOR) to the start of the trip (Start trip).

We see this as the bottleneck of the process. Also, trips are carried out without approval, which is a deviation.

Throughput Time of Subprocess

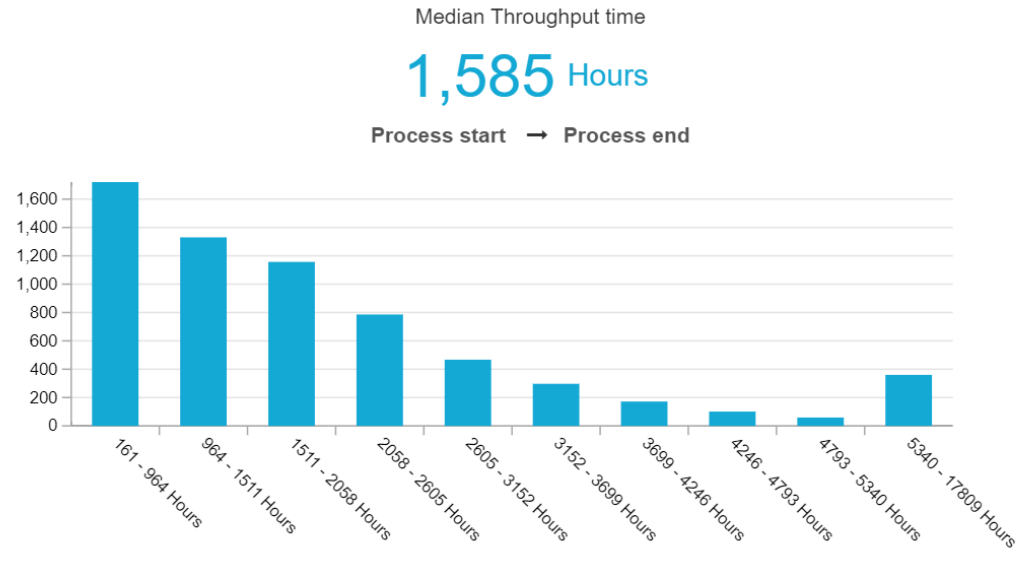


Fig. 8. Throughput time of processes.

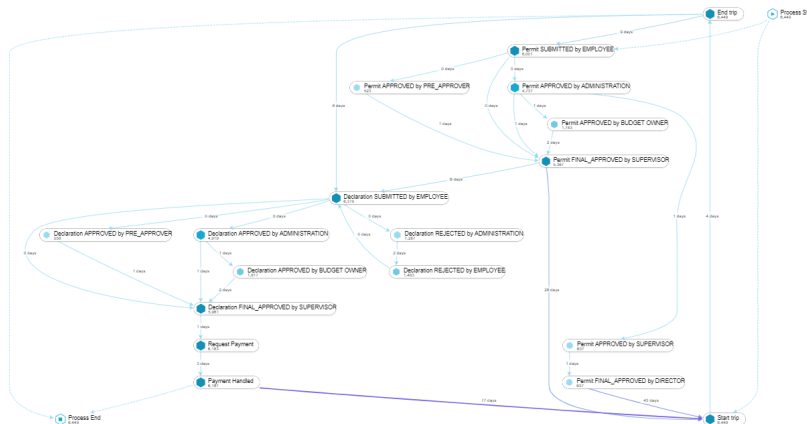


Fig. 9. International declaration median graph.

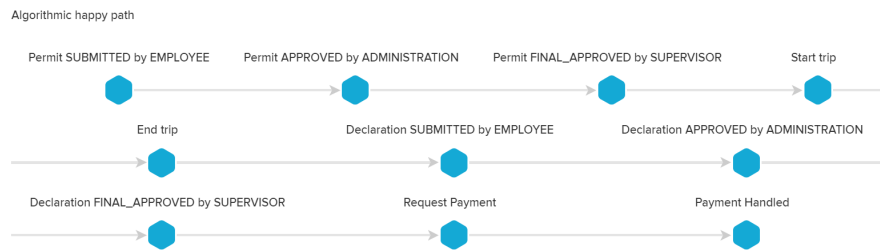


Fig. 10. Algorithmic happy path.

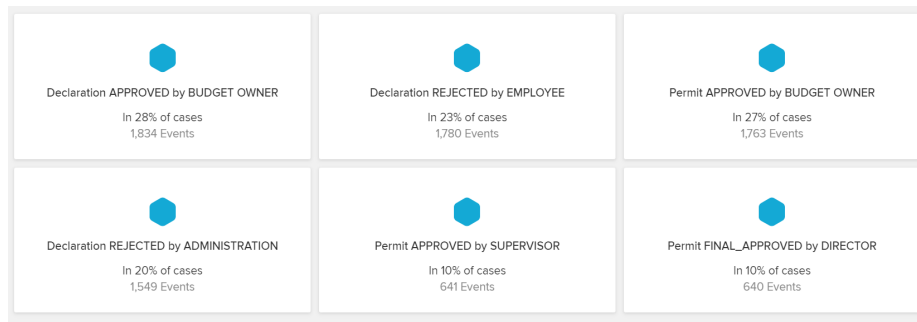


Fig. 11. Other frequent activities.

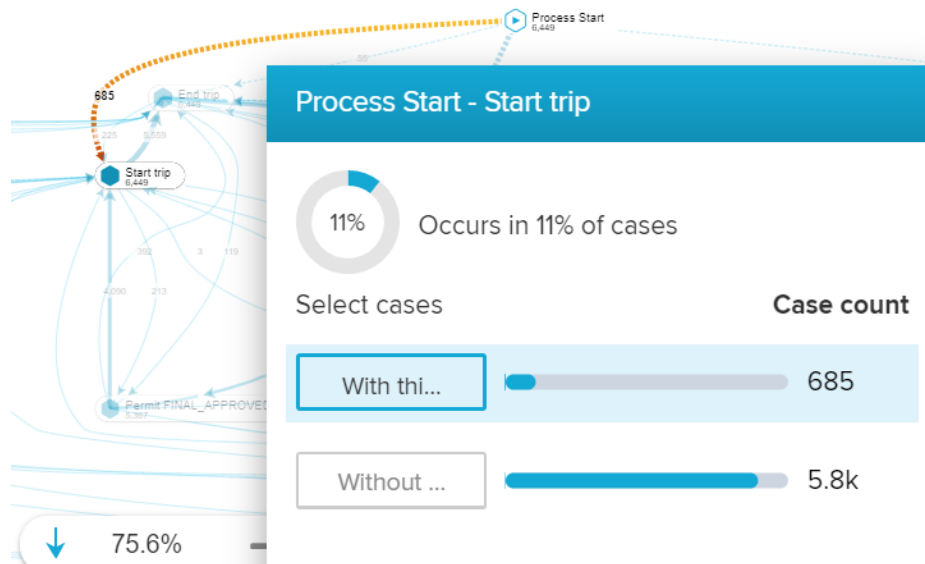


Fig. 12. After the trip, permits are agreed and the payment of travel allowances.