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Simulation of administrative labour costs in seaport clusters

Edvard Tijan[1], Saša Aksentijević[2], Bojan Hlača[3]

[1] University of Rijeka, Faculty of Maritime Studies, Studentska 2, 51000 Rijeka, Croatia
[2] Aksentijevic Forensics and Consulting Ltd., Gornji Sroki 125a, Viškovo, Croatia
[3] University of Rijeka, Faculty of Maritime Studies, Studentska 2, 51000 Rijeka, Croatia

ABSTRACT

The paper researches the usage of simulation approach using FlexSim software package in order to create a viable model of administrative document flow during ship arrival and departure in conventionally operated seaport clusters that do not utilize Port Community Systems. Goal of the modeling was to create a simulation model that would be used to reliably calculate the average total time required for the full document flow related to ship's arrival and use the end result to estimate the cost of labor related to involved manual work. This estimation will be used as a basis for further research into possibilities of process reengineering and suggestion for process improvements.

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1. Introduction

The main goal of modeling and simulation in seaport clusters (and in general) is to research data and information related to behavior of the system based on research of the model, and not by direct insight into the system itself. During the next step of research, after the model is created, it is possible to perform experiments in order to gather more data regarding the existing or future state of the system. Systems can be quite diverse because they exist in different areas of interest. Inside the given area, additional systems may exist, but with a different set of goals. For the same system, different models can be devised depending on the goals, modeling approach, different means used to model and simulate, different level of knowledge of those creating the model, etc. If different systems are accounted for, a number of possible variations significantly rises.

Research of the system by using the modeling requires thorough definition of questions whose answer should be derived from simulation process. Usually, the modeling inclusion criteria requires that only those aspects of the system relevant for the research are included. All other aspects are disregarded as much as possible in order to simplify the model. Modeling and simulations are usually used to research complex systems, so it is important to exclude all those elements that would make the model even more complex, but do not contribute significantly towards quality of the received answers to underlying questions. Modeling procedure consists of several sequential steps, while final two stages, simulation experiment and analysis of results are repeated until the research is completed and the data related to set model is acquired. This process is shown in Fig. 1.

The model usually shows a static situation of the system at a given moment. The state of the system is represented by the state of a number of significant parameters. Simulation process is in fact a time-bound execution of the system state in a given time frame. (Smiljanić, 1995.)

2. Simulation and modeling of ship's arrival document processing in port clusters using software package flexsim

Simulation enables quantitative analysis of business processes that use certain resources in time. Business systems include a large quantity of connected elements, random variables and people involved in the process. Simulation will provide answers to *"what if"* scenario questions, for example, what will happen if demand for the product rises, if a machine in a production facility is malfunctioning or a document in a business process is late in arrival. The same can be applied to seaport cluster processes. Simulation is used in complex systems in which it is not feasible to create a mathematical model or in which real system experiments are too expensive, dangerous, last too

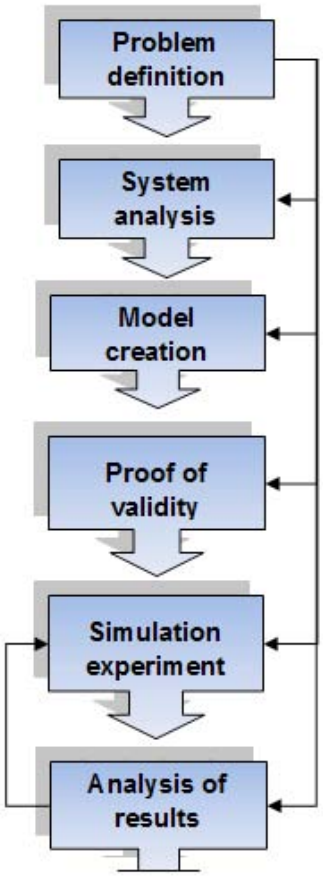

Fig. 1 Modeling process, from problem definition to result analysis (Čičak, 2005., p. 15)

long or they are simply not possible. During the simulation process, all parameters must be under researcher's control and must enable reliable conclusion and useful suggestions for business decision making.

The main issue with models is that their construction is never complete – model creation is practically an endless process. Models must be constantly remodeled and loaded with new data that is constantly changing, and the model has to be structurally changed and updated. This is also relevant for business process model of seaport clusters. Administrative and commercial processes in seaport clusters are prone to changes due to legal or technical and technological changes. Therefore, models need to be constantly reconstructed and simulations need to be cyclically performed on those models. (Afrić, 1999, p. 108)

The main hypothesis of the research is that it is possible to simulate business and commercial process of the seaport cluster by using computer modeling software. In order to prove the hypothesis, a simulation approach was executed by using computer modeling and simulating application Flexsim 5.1.2 by FlexSim Software Products Inc., Utah, USA. FlexSim is a tool used to model, simulate and visualize business processes. It enables creation of models in different business areas like logistics and production. FlexSim is used to solve various problems: determine and analyze production capacities, identify and manage bottlenecks, solve optimal storage and warehousing problems, verify deadlines, help during engineering phase of technological processes, and understand the systems and document flow requirements. (Galović, et al., 2011)

FlexSim is a tool primarily used to simulate discrete events. Discrete simulations are used to describe systems and its elements in details. System behavior is described in a non-continuous manner, as a sequence of different events and activities. Models mimic real systems and processes – objects within models represent objects present in real systems and processes. Discrete simulations are primarily used to model and analyze systems with waiting queues and compare them towards available system resources. Discrete simulation is describing state changes as a consequence of interactions between system objects. Simulation models show object systems, their attributes and interactions.

Discrete simulation models contain random variables that can be multi-state and depend on a certain possibility distribution (service intervals or arrival intervals). Fluctuations of values of random variables are being spread throughout the system because of live element interaction. Most such variables show random fluctuations, so it is necessary to use probability theory and statistics during generation of random variables, analysis of input data, planning of simulation experiments and analysis of the simulation experiment outputs. During the simulation execution, time is changed in a non continuous manner, from

the moment when the last event occurred until the moment when the next event will occur. Simulation clock is measuring the elapsed simulation time. Activity is interaction of entities that has an exact predetermined length and during its execution entity state does not change.

3. Basic model parameters and prerequisites

Seaport clusters are geographic concentrations of internally connected companies, specialized suppliers, service providers and associated institutions. (Toh, et al., 2010) The main steps of the modeling of processes in seaport clusters is to create a model by using objects from the embedded library, adjust the outline and behavior of every object, run the simulation and check the output results. FlexSim model is a system that consists of waiting queues, processes and transport. Object modeling includes fixed (queues and machinery) resources, standards resources (operators) and mobile resources (forklifts, elevators and similar). Entities (subjects) allow flow from one fixed resource to another. These entities contain information that can be entered into the model to define process and guide decision making. Sometimes entities are transported to the next fixed resource using a mobile resource, but sometimes they are momentarily transferred (as it will be the case in this model). Most information required to model are defined within fixed resources, inside the model, for example:

- time required to process entities
- destination of the next entity
- calls to the standard resource (for example, operator) to process,
- call to mobile resource to transport entity to the next fixed entity.

FlexSim possesses its own unique terminology. Objects are a part of the library and accessible through graphical user interface and they are entered into the model by dragging motion actions. Entities are objects flowing through the model process path (employees, products, palettes etc.). In our research, we have studied an administrative process of ship arrival in the port and related document flow in order to determine the time required to complete the process and to estimate related costs. Entities are defined as sets of forms, certificates or documents and individual documents, forms or certificates. In our simulation, entities are being transported inside the model through different objects where they are processed. Processing time corresponds to the real time of document and form processing. Entities also flow through combiners that aggregate (or combine) documents and forms. Entities are created at their source and disappear (become archived) in sinks. Task type is a designation dividing entities by number, product type or in some other way. Every object in FlexSim model has an unlimited number of connections with other objects, effectively establishing communication with other objects.

In order to create a simulation model, basic model premises related to administrative process of ship arrival announcement were created as follows:

- The company has submitted all required information about the ship to the agent. Agent is in possession of all required information to fill the forms and all required certificates are available,
- The ship will not be berthed outside of the customs area or area under control by the border police, therefore eliminating the usage of applicable documents,
- The ship is transporting some sort of dangerous cargo (at least one type),
- All forms and certificates are accepted and there is no rejection from the side of the port authority, port control center, border police, sanitary inspection or customs,
- There is no waiting period for the document approval; modeling presumption is that port governance bodies will immediately check and approve the documents and next step in the process – there is no waiting period to process forms and certificates,
- There is no need to secure the ship by using the guard service which is in reality sometimes done depending on the risk assessment (determination is done according to the ship's flag),
- There are no interruptions in delivery of ICT services and ICT services are 100 % readily available (some of the forms are sent by e-mail),
- The simulation model encompasses only the time domain: time required to complete individual tasks within the administrative domain of the ship's arrival announcement.

After the simulation was completed and an average duration of the process was estimated, it served as a basis to estimate the labor cost for the conventional processing of the ship's arrival announcement documents. The following premises were applied during financial impact estimation:

- For simplicity's sake, all labor invested in document processing is being paid as a labor of water transport staff, according to National classification of economic activities (Anon, 2007), even though, in reality, personnel from different branches of the classification is involved, for example, police officers, customs officers and sanitary inspectors,
- No fixed or relatively fixed cost of labor is being attributed to the process in this model, all cost consists of variable gross pay for performed labor and fixed labor cost is excluded from the model,
- Administrative cost of labor is excluded (depreciation, rental, ICT cost, electricity, taxes, accounting). All related cost is covered and attributed to other cost centers,
- Labor and salary are infinitely divisible,

Table 1 Documents related to ship's arrival and departure (Tijan, 2012.)

#	Document title
1	Notice of Arrival
2	IMDG Reporting form (DCRForm)
3	Ballast water reporting form
4	Notification of ship-generated waste
5	ISPS CODE Arrival notification
6	Dangerous Goods Manifest
7	Notice of Arrival for mandatory expanded inspection
8	Special Cargo Stowage Plan
9	Maritime declaration of Health
10	Declaration of Dangerous or polluting goods (DECL.o.t.-1/3)
11	Vessel Arrival Notification (PP/M-31a Form)
12	Permission for a vessel to have communications with the shore (UT-VI-222)
13	Vessel Departure Notification (PP/M -31b Form)
14	Permit of Vessel's Departure (UT-VI-223)
15	List of forms when notifying arrival/departure of vessel from HMO
16	Berthing, unberthing and shifting of vessels report
17	International Dangerous Cargo Manifest
18	Ship/shore safety check list – tankers
19	Safety check list for handling dangerous goods other than tankers
20	Ship/shore safety checklist for loading or unloading dry bulk cargo carriers
21	List of vessels berthed in port basins
22	Minutes from Coordinating-operative meeting
23	Vessel announcements on the day:
24	Dangerous Cargo Plan
25	Ship sanitation control exemption certificate/ship sanitation control certificate
26	Sanitary Free Pratique
27	Permit for ship departure (customs clearance to Harbor master)
28	IMO Crew List (IMO FAL Form 5)
29	IMO Passenger List (IMO FAL Form 6)
30	Preliminary Stability Calculation (INBOUND)
31	Preliminary Stability Calculation (OUTBOUND)
32	NIL List (Arms, Ammunition, ...)
33	Narcotics List
34	Crew's Effects Declaration (IMO FAL Form 4)
35	Ship's Stores Declaration (IMO FAL Form 3)
36	List of ports of Call
37	Request for berthing outside the customs area
38	Request for berthing outside the maritime frontier crossing
39	Agent's declaration of covering costs of stay, deportation or repatriation
40	Customs Manifest (Outgoing)
41	Cargo Manifest
42	Outgoing Customs Declaration

Table 2 Certificates related to ship's arrival and departure

#	Certificate Name
C1	Bunker Convention Insurance
C2	International Ship Security Certificate (ISSC Certificate)
C3	Anti-Fouling System Statement of Compliance (AFC)
C4	Oil pollution insurance – (Civil Liability – CLC)
C5	Wreck Removal Insurance – (Civil Liability – CLC)
C6	Document of Compliance for the Carriage of Dangerous Goods

- Work can be performed in a continuous manner, there are no interruptions or delays, as one action is completed it is immediately handed over to the next instance in the process chain,
- The gross labor costs consists of net salary, income tax, pension insurance and employer's contribution
- The personnel performing the work resides in the area with 16 % surtax.

4. Documents flow related to ship's arrival announcement

To create a model, all documents and certificates related to ship's arrival announcement had to be identified. The documents related to ship's arrival and departure are shown in table 1.

Furthermore, there are several standardized certificates, identified as requirements for processing of the ship's arrival. Six such certificates are shown in table 2, along with their standard codification.

After the documents and standard certificates involved in the preparation for the ship's arrival were identified, it was possible to survey the process of the document flow and to show it graphically. It served as an algorithm to be translated into FlexSim model.

Fig. 2 shows the flow of existing process of filling, delivery and checking of forms and certificates during ship arrival announcement.

The field research was performed in form of an interview. In order to determine the time required to complete the sub processes shown in Fig. 2, interviews were performed with relevant stakeholders and involved parties. Questions were asked to several involved agents to estimate the time required to perform actions under their jurisdiction. Simple averages and standard deviations were calculated for each of the steps. Furthermore, for some actions that involve ICT technologies and do not rely solely on human action (sending emails, faxing), estimates were included in the model. Some of the actions involve issuing or dealing with several documents, so in that case a longer processing time may be expected.

Table 3. shows the results of the interviews that determine individual process step times and applicable estimations.

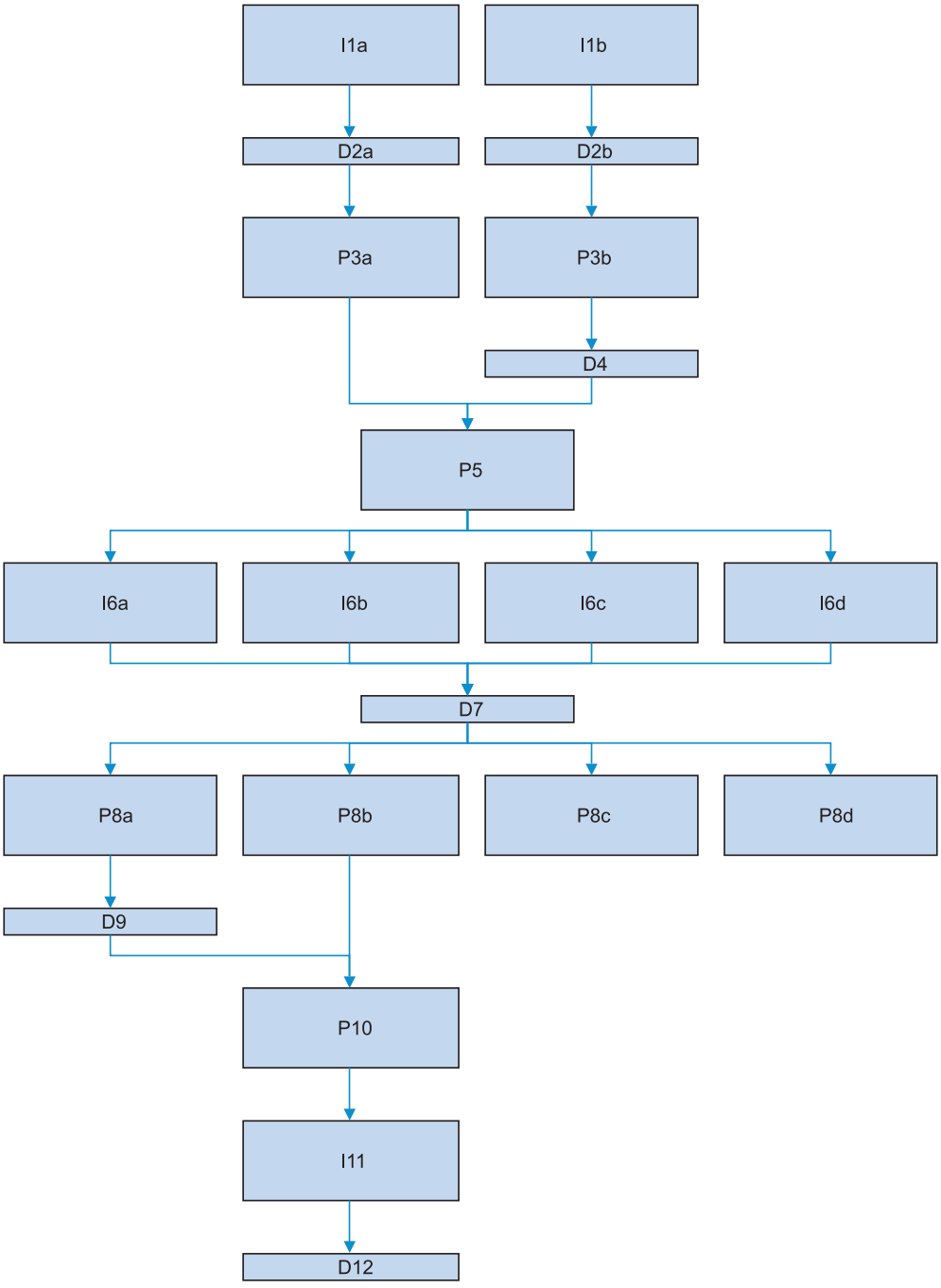

Fig. 2 Processing algorithm for ship's arrival documentation

5. Simulation model's process paths

Based on the outlined premises, a model has been created by using FlexSim. Elements of the model represent individual sub processes within actions of filling, delivering and checking forms and certificates during ship's arrival announcement. The processing time has been programmed for each of the corresponding elements, and it is equal to the time determined by using interview and estimation methods, as described in table 3. This type of simulation model calls for several sourcing and output points and endpoints (sinks) because of the fact that each document or a set of documents has to be created in at least one element and end up in at least one element of the model.

Graphical representation of the model is shown in Fig. 3, along with detailed explanation of the process paths already mentioned in Fig. 2.

Source point NOA is the beginning of the process of form (document) creation to announce ship's arrival (I1a), deliver the document to the Harbormaster's office (D2a) and check the documents (P3A). ARH1 represents archiving of the applicable forms.

Table 3 Survey of average time required to complete individual documentation tasks related to announcement of ship's arrival

Process designation	Process description	Average time to complete	Standard deviation	Required documents and certificates
I1a	Completion of Notice of Arrival form (filled by the captain or ship's agent)	31,67 min (N=6)	11,25 min	#1, #2, #3, #4, #5, #6, #7, #28, #29, C1, C2, C3, C4, C5
I1b	Completion of Ballast water reporting form, Notification of ship-generated waste and IMDG Reporting form (DCRForm)	115 min (N=6)	22,58 min	#8, #10, #17, C6
D2a	Delivery of forms, cerfificates and ISPS CODE Arrival notification to the Harbormaster	2 min (estimation)	1 min (estimation)	e-mail
D2b	Delivery of forms and certificates to the DG inspector of the port authority	29, 17 min (N=6)	9,17 min	-
P3a	Harbormasters' office checks forms and certificates related to Notice of Arrival	31,67 min (N=3)	12,58 min	-
P3b	Dangerous Goods inspector is checking Declaration of Dangerous or polluting goods, Special Cargo Stowage plan, certificate Document of Compliance for the Carriage of Dangerous Goods and approves (by stamping) Anti-Fouling System Statement of Compliance (AFC)	17,5 min (N=2)	3,54 min	#10
D4	Delivery of the acknowledged Declaration of Dangerous or polluting goods to the Harbormaster's office	2 min (estimation)	1 min (estimation)	-
P5	Harbormaster's office is validating acknowledged Declaration of Dangerous or polluting goods	10,83 min (N=3)	3,82 min	
I6a	Ship's agent is completing Maritime declaration of Health and Ship sanitation control exemption certificate/ship sanitation control certificate	27,50 min (N=6)	9,87 min	#9,#25
I6b	Ship's agent is completing form Vessel Arrival Notification	28,33 min (N=6)	4,08 min	#11
I6c	Ship's agent is completing Customs Manifest (Outgoing)	33, 33 min (N=6)	9,83 min	#10, #33, #34, #35, #36, #41
I6d	Ship's agent is completing forms relevant for border police activities	30,83 min (N=6)	8,01 min	#10, #28, #29, #32, #33, #36, #39
D7	Delivery of forms to sanitary inspection, Harbormaster's office, customs and maritime border police (onboard delivery)	175 min (N=6)	22,58 min	-
P8a	Sanitary inspection is signing (acknowledging) Ship's sanitation control exemption certificate/ship sanitation control certificate and issuing Sanitary Free Pratique document	27,50 min (N=6)	9,87 min	#25, #26
P8b	Harbormaster's office is checking form Vessel Arrival Notification	11 min (N=3)	3,61 min	#11
P8c	Customs office is checking the submitted documentation	37,50 min (N=2)	10,61 min	#10, #33, #34, #35, #36, #41
P8d	Border police is checking the submitted documentation	35 min (N=3)	8,66 min	#10, #28, #29, #32, #33, #36, #39
D9	Delivery of approved Sanitary Free Pratique document to the Harbormaster's office	1 min (N=6) (estimation)	0,35 min (estimation)	-
P10	Harbormaster's office is verifying Sanitary Free Pratique document and is contacting customs office and maritime border police	21,67 min (N=3)	7,64 min	#26
I11	Harbormaster's office is issuing Permission for a vessel to have communication with the shore	16,67 min (N=3)	2,89 min	#12

Source point IMDG is the beginning of the process that fills forms related to dangerous cargo (I1b), delivers them to the inspector in charge for dangerous cargo within port authority (D2b), checks them (P3b) and delivers validated and apostilled declaration to the port authority. (D4). At the end of the process, the port authority is checking delivered declaration form (P5).

ARH2 represents the end of the process of approval of the declaration related to dangerous material and pollutants by the port authority, and it serves as a trigger for sources POL, CAR, LK and SAN. In fact it serves as a beginning of the creation of documents related to ship's arrival announcement.

Source point POL is a beginning of the process that fills forms that have to be submitted to the maritime border police (I6d). Source CAR is a beginning of the process of filling forms to be submitted to the customs (I6c). Source LK is a beginning of the process of filling forms related to Harbormaster office procedure (I6b). Source SAN is a beginning of the process of filling forms related to sanitary

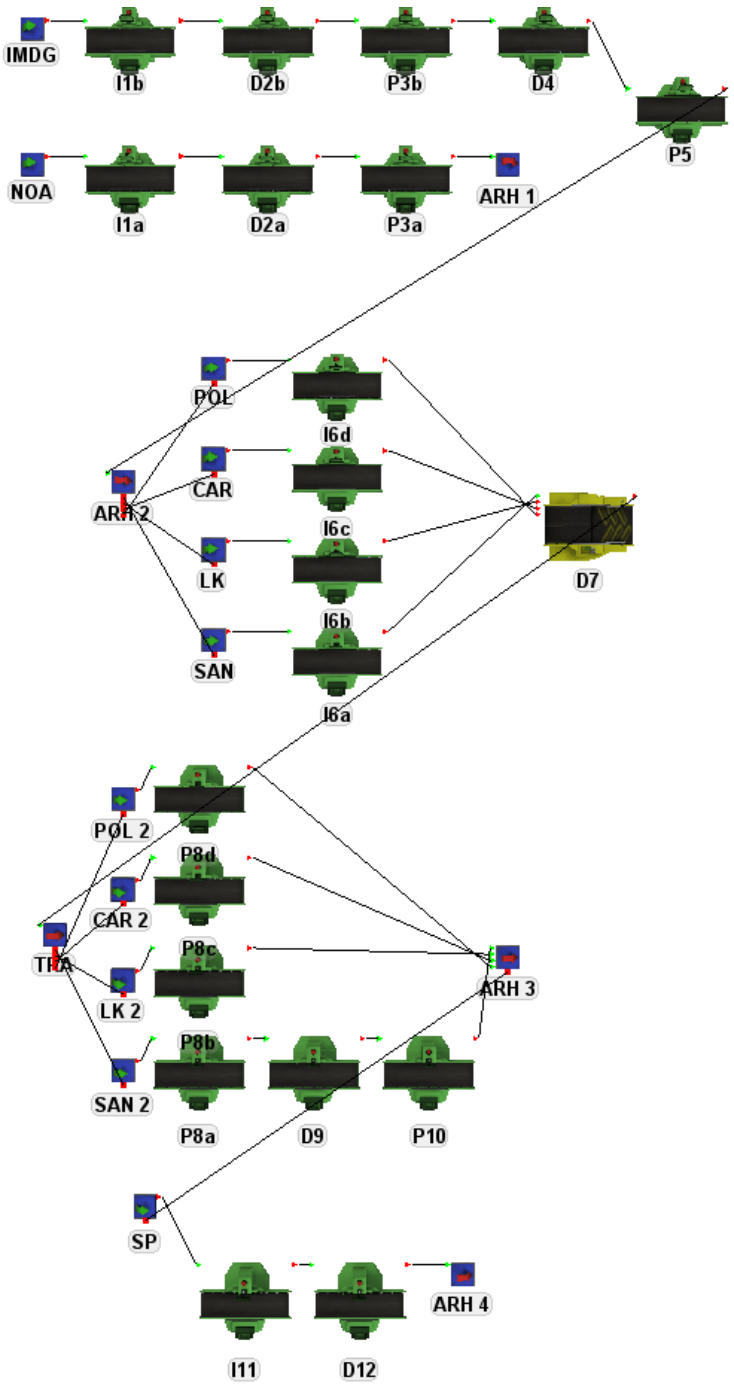

Fig. 3 Graphical representation of the model of ship's arrival announcement documentation in conventionally operated port clusters

inspection procedure (I6a). Considering that all paper forms are physically carried onboard to be checked, the simulation model includes combiner D7 where all sets of documents originating from sources POL, CAR, LK and SAN that were processed using processors I6d, I6c, I6b and I6a are being aggregated. TRA represents end of the delivery (transport) of all documents onboard the ship and at the same times it triggers sources POL2, CAR2, LK2 and SAN2 – beginning of the verification of the documents related to ship's arrival announcement.

Source POL2 presents the beginning of the form verification on behalf of the border customs (P8d). CAR2 is related to customs activities, LK2 is the beginning of the same verification process by the port authority (P8b) and SAN2 is the beginning of the form verification by sanitary inspection (P8a). Sanitary approval release to port captain is represented by D9, and verification of that form by the port captain is represented by process P19. ARH3 presents end of all described processes that are in fact check and verification of submitted forms, and it triggers the source

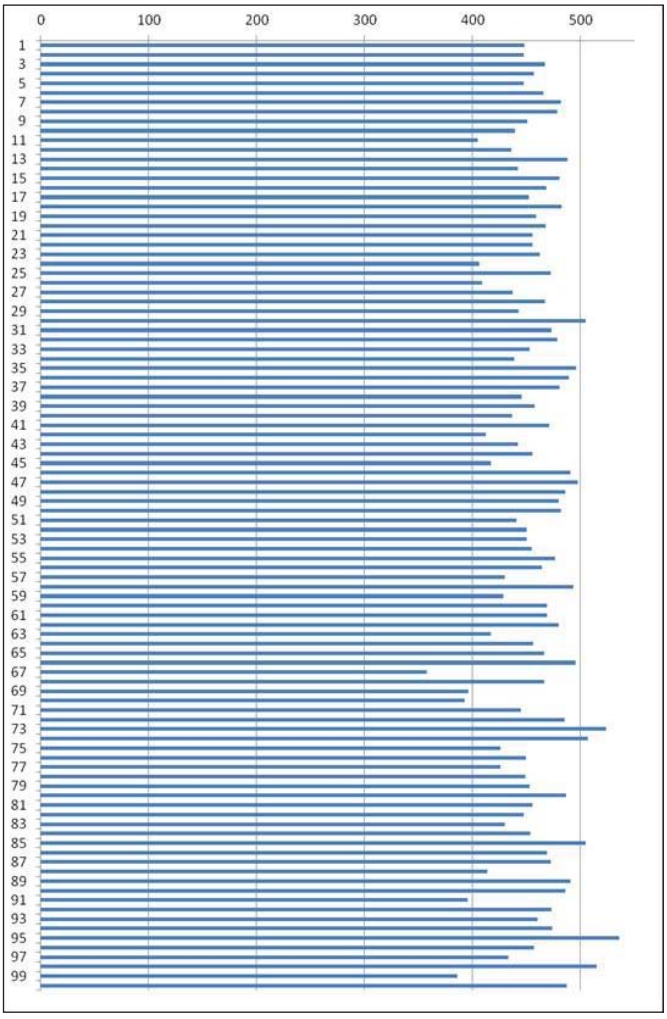

Fig. 4 Results of simulation experiments of the conventional administrative process of ship's arrival to port

SP – the beginning of creation of Permission for a vessel to have communication with the shore (I11).

After this approval has been released by the port captain and delivered to the ship's captain as a part of D12 process, it ends in ARH4 endpoint.

6. Results of the simulation model

Based on the described simulation model, 100 simulation experiments were performed by using FlexSim that have resulted in the following results, shown in fig 4. The shortest run time was 357,56 minutes and the longest run time was 535,59 minutes. Simple average value of the results was 457,95 minutes.

In order to derive some direct translations into monetary value, it was necessary to establish a relation between time spent and monetary value. According to Croatian Bureau of Statistics (Anon, 2014), average net monthly salary paid in December 2013 in the water transport activities (NKD H-50) was 6.650,00 Kn. Based on an employee working and living in a municipality with surtax of 12 %, gross salary for that net salary would amount to 9.915,58 Kn and gross salary with paid employee contributions (total cost for the employer) would amount to 11.427,36 Kn. This leads to conclusion that an average labor cost in administration of ship incoming arrival announcement activities (based on 23-working day month) would be 62,11 Kn (8,15 EUR; 1 EUR=7,62 Kn).

In average, the time required to process documents related to single ship's arrival amounts to 7,63 hours and the related average administrative labor cost under these assumptions would be 474,05 Kn (62,21 EUR). Similar conclusions could be drawn for all port clusters that use similar documents and conventional processes and do not employ information and telecommunication solutions on a level higher than pure operational support (e-mail and Web browsing). These costs are pure administrative labor costs devoid of any related fixed or relatively fixed costs, under outlined model assumptions.

Significant improvements to the time consumption of ship's arrival to port can be expected after process reengineering and especially after introduction of Port Community Systems that would result in increased efficiency and variable labor cost reduction. These assumptions form the base for future research in this area.

7. Conclusion

Conventional management of document flow during announcement of ship's arrival to port ties up significant resources, and one of them is human labor. Several dozens of applicable documents exist, along with six identified certificates. Most of the documents are manually filled (completed), hand carried between various instances in charge of the process (port authority, Harbormaster's office, police, customs, sanitary inspection, ship's agent and ship's captain). There are significant gaps and delays in the document delivery, and overlapping in activities.

By using a simulation model set up in FlexSim application, it was possible to set up an algorithm, define elements, sources and rules of the document flow and to run a simulation whose simple average represents average time required to complete the flow of required documents to announce ship's arrival. In average, it takes at least 7,6 hours of continuous work time to process the necessary documents. By using statistical data for the labor cost in water transport, it was possible to estimate the labor cost for this process and to calculate it on the level of a single port cluster, according to the average number of ships that call the specific port yearly.

This simulation model could serve as a starting point for reengineering of ships' arrival announcement process that should results in significant financial savings, but also resulting in freeing up tied resources for other tasks. In the next step, this analysis may be used to compare costs with those incurred in an optimized environment, or port clusters that use integrated business information systems

specifically created for usage in port clusters – Port Community Systems.

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