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APPLICATION OF OPERATIONS SCHEDULING ALGORITHMS FOR THE ALLOCATION OF FORENSIC SCIENCE SERVICES: A CASE STUDY

APLICAÇÃO DE ALGORITMOS DE PROGRAMAÇÃO DE OPERAÇÕES PARA ALOCAÇÃO DE PERÍCIAS CRIMINAIS: UM ESTUDO DE CASO

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Abstract: The activities of preparing and issuing Forensic Science Services reports are a public service of great importance for society and for the executive and judicial branches. However, notably, it has difficulties in meeting due dates, causing damage to all involved and generating additional costs for governments. In practice, it is observed that knowledge in the area of operations management is not used to determine the allocations of Forensic Science services at Criminalistics Technical Sections. Therefore, the objective of this research is to develop and apply knowledge related to the operations scheduling of Forensic Science reports. To fulfill the objective, the case study research method was applied in the Regional Technical Section of Criminalistics (STRC) of Três Corações - Minas Gerais in Brazil. Real data from that Forensic Unity carried out in the past were implemented in an APS (Advanced Planning and Scheduling) software and new allocations, based on the software's internal algorithms, were carried out. The results of allocations from the software have been compared with the previous results. The comparisons show that scheduling from the software's algorithms can bring better results.

Keywords: Production Planning and Control. Operations Scheduling. Advanced Planning and Scheduling. Forensic Science. Public Safety.

Resumo: As atividades de elaboração e emissão de laudos de perícia criminal são um serviço público de grande importância para a sociedade e para os poderes executivo e judiciário. Porém, notadamente, possui dificuldades em cumprir prazos de entrega, causando danos para todos os envolvidos e gerando custos adicionais para os governos. Na prática, observa-se que conhecimentos da área de gestão de operações não são utilizados para a determinação das alocações dos laudos periciais nas seções técnicas de criminalística. Por isso, o objetivo da presente pesquisa é desenvolver e aplicar conhecimentos relacionados à programação de operações em atividades de alocação de laudos de perícia criminal. Para cumprir o objetivo foi aplicado o método de pesquisa de estudo de caso na Seção Técnica Regional de Criminalística (STRC) de Três Corações – Minas Gerais. Dados reais de perícias realizadas no passado foram implantados em um software do tipo APS (Advanced Planning and Scheduling) e novas alocações, a partir dos algoritmos internos ao software, foram realizadas. Os resultados das alocações a partir do software foram comparados com os resultados anteriores. As comparações mostram que a programação a partir dos algoritmos do software pode trazer melhores resultados.

Palavras-chave: Planejamento e Controle da Produção. Programação de operações. Planejamento e programação avançados. Perícia Criminal. Segurança Pública.

1 INTRODUCTION

Among the public services that most influence people's daily lives are those of public safety and criminal justice. The lack of this service or its poor provision can bring a lot of damage to society. For example, Freedy et al (1994) report that crime victims involved in the criminal justice system are at risk for developing post-traumatic stress disorder. One of the agents of this public service chain is the Forensic Science Service (FSS). The FSS is the agency in charge of producing scientific material evidence, which transformation resources are scientific knowledge and the technologies applied to process the traces found at crime scenes. The FSS is essential in reducing crime because it increases the chances of a successful investigation into crimes and a fair trial. Forensic evidence has scientific validity and, at the same time, helps in the promotion of human rights, preventing suspects from being subjected to physical and psychological constraints.

An event that generates the need for a criminal investigation represents the demand for this public service and the FSS report with the forensic scientists' conclusions represents the delivery, that is, the fulfillment of the demand. One of the first decisions to be made in this process is the allocation of the task of preparing the FSS report to one of the forensic scientists on duty at Criminalistics Technical Section. Notably, the allocation of resources to perform tasks is the first decision in operations scheduling problems (Baker, 1974). At FSS unities, such allocation is made based on the experience of the head of the Criminalistics Technical Section. Simplifications like this in decision making in operations scheduling are common in practice, mainly due to the complexity inherent to these problems, however the results obtained in such situations are not necessarily satisfactory (Carvalho *et al.*, 2014).

The FSS has complex management (Koppl, 2005, P. 256; Brasil, 2006) and several opportunities for improvement. One of the most urgent opportunities for improvement in the provision of the FSS is to meet the due dates (Rodrigues; Toledo, 2015a; Rodrigues; Toledo, 2015b; Belluco; Pimenta, 2013; Gonçalves, 2013; Lima; Goldszmidt, 2013; Houck *et al.* 2012; Brasil, 2012, p. 101-104). An example is São Paulo, whose fact was reported in the national press (Soares, 2015; Zúnica, 2014), but it can be extended to other units of the federation, as shown by the

document of the Ministry of Justice in Brazil (Brazil, 2012). In part, such delays can be attributed to the lack of methods for allocating the tasks.

Although there is a need to apply operations scheduling knowledge in such services, recent literature shows that there are still gaps to be filled. Research on scheduling has been carried out based on various topics such as I4.0 (Ghaleb *et al.*, 2020; Parente *et al.*, 2020; Hu *et al.*, 2020) and supply chain management (Jamrus *et al.*, 2020; Solina and Mirabelli, 2021; Chavez *et al.*, 2020), but little research deals with scheduling in services. In a survey considering case studies in operations scheduling, Fuchigami and Rangel (2018) found that there are no articles in the literature that address service companies. Based on a literature review, Carvalho *et al.* (2014) argue that there is a gap in research related to operations scheduling when it comes to applications in real contexts. More recently, Parente *et al.* (2020) also conclude that more research is needed on operations scheduling problems.

The present work aims to fill some of the identified gaps. First, the research detailed in this paper presents a case study carried out in a service organization. More than that, the case study was carried out in a public agency, in a FSS, which, according to the authors' knowledge, is unprecedented in the literature related to operations scheduling. Thirdly, the results obtained in this research offer opportunities to improve the provision of this service to clients (judges, prosecutors, defense attorneys, police investigators, etc.) and other stakeholders, such as victims, suspects, media and political agents.

The objective of this research is, using real data from a Forensic Science Unity, to apply algorithms of an Advanced Planning and Scheduling software and to compare the results obtained by the software with the results and scheduling obtained previously (without the use of the software). When defining this objective, the researchers supported themselves in the hypothesis that APS systems greatly assist the sequencing and dispatch of orders offering good results, as shown in Ivert (2012).

The structure of this paper is as follows: in sections 2 and 3 the theoretical references of the study are presented; in section 4 the research method are explained; in the section 5 the case study and results are described in detail; and, finally, in section 6 the final considerations are made.

2 PUBLIC SAFETY AND CRIMINAL JUSTICE SERVICES CHAIN AND FORENSIC SCIENCE OPERATIONS

The FSS is part of a supply chain of public safety and criminal justice services. This chain must deliver a justice value to the society in general, and the final product is the condemnatory or absolute judicial sentence.

According to the law, the ostensive or patrol police (Military or Highway Police), upon learning of a fact, must go to the scene, isolate it and call the Investigative Police (Civilian Police), who will take over the case, while the ostensive Police return to patrolling. If there are traces any at the crime scene, the police investigator will request the Forensic Science services and preserve the crime scene until the forensic scientist (in this case, a Crime Scene Investigator - CSI) arrives, immediately starting the investigation (Brasil, 1941, Art. 6).

The legislation determines the obligation to carry out the forensic science examination in every criminal infraction that leaves traces, under penalty of nullity of the criminal process. These examinations must be carried out by a CSI (BRASIL, 1941, arts. 158-159). The forensic scientists enjoy technical, scientific and functional autonomy (Brazil, 2009) and are considered auxiliary to the Justice System.

The FSS is complex, as it has interfaces with the technical-scientific, police and legal spheres (Misse *et al.*, 2006). It is a professional service (Mintzberg, 2009, P. 212; Silvestro, 1999), where, in many cases, the forensic scientist must apply to the specific case the knowledge learned during the university course - engineering, medicine, dentistry, pharmacy, physics, chemistry, biology, geology, computing, accounting sciences etc. - and in the professional training course (Rodrigues, 2010, p. 124).

The service process begins with triggering, as a rule, by the Civilian Police. When the crime scene is external (homicides, work accidents, robberies, kidnappings etc.), the CSI moves and transports all the necessary material to the crime scene. On site, the CSI draws sketches, takes photographs, takes measurements, documents and collects materials for complementary examinations (Rodrigues, 2010; Rodrigues *et al.*, 2010).

After the crime scene exams, the CSI returns to the FSS Office and, if necessary, requests laboratory exams and / or other specialized exams from the back office of the service, such as DNA, ballistic, toxicological, chromatography, among others. At the back office, the service is organized functionally into specialized units such as forensic biology, legal physics, legal chemistry, forensic ballistics, for example. Subsequently, the forensic scientist prepares the report, which contains the examinations and conclusions, and send it to the client who requested it (Rodrigues, 2010).

In the judicial phase, the forensic scientists may be subpoenaed by the judge to answer questions (questions about points of the report) in writing or personally attend the hearing at the criminal trial to provide clarification on the FSS report in a specific case. The frontline operations operate 24 hours a day, seven days a week (Rodrigues; Rachid, 2006; Rodrigues, 2010; Rodrigues *et al.*, 2010).

Notably, the FSS presents several opportunities for improvement. One of the most urgent is the dependability, as evidenced by Soares (2015) and Zúnica (2014) and as shown by the document of the Ministry of Justice for the diagnosis in Brazil (Brazil, 2012). The delay in making available FSS reports harms the police investigatons, public prosecutors in the criminal courts suits, defense attorneys in defining the best defense strategy and judges in their sentences, thus making value delivery more difficult.

The main problems related to the delivery of reports are the scheduling of services (examinations and reports) and the finite capacity on personnel, buth forensic scientists and clerical workers.

3 THE CONTRIBUTION OF THE OPERATIONS SCHEDULING TO THE FSS

When orders arrive in a production or service system, a decision must be made on the order in which the tasks will be performed. This priority is often established by simple rules, for example, First-Come, First-Served (FFSS) and Earliest Due Date (EDD), both widely used in practice. However, for most situations, these simple rules do not provide good results (Slack et al., 2009; Chase et al., 2006).

Production scheduling occurs at four levels in the planning process; aggregate scheduling, and product completions (MPS), and the sequencing of jobs on machines (Buxey, 1989). According to Morton and Pentico (1993), operations scheduling is the process of organizing, choosing and timing the use of resources to carry out the activities necessary to produce the desired outputs at the desired times, while satisfying a series of time restrictions and relationships between activities and resources. This definition calls attention to three important points: resources are used, the outputs are related to objectives and there are restrictions. Notably, for any system, resources are always limited. Still, the system needs to achieve its objectives, for example, serving customers on time. And any and all tasks must be performed according to their productive route, that is, there are stages to be fulfilled and that are interdependent. Given these characteristics, operations scheduling is an complex activity, because if only the number of different sequences to perform n tasks is considered, the difficulty is already great, since they are n! possibilities to be analyzed for decision making.

Another difficulty in operations scheduling is keeping the schedule up to date. This is because unforeseen events occur in the production systems: machines break down, workers are missing, suppliers delay deliveries, etc. Thus, the recently planned programming, even with very well elaborated methods, loses its effectiveness in a short time. In other words, in unstable environments, in order for the objectives to be achieved, the production schedule must be redone with a very high frequency.

Due to these difficulties in solving operations scheduling problems, on the one hand, many researches are focused on the development of heuristic algorithms for their realization. On the other hand, many of these heuristic algorithms are included and developed to work in software that allows to do the scheduling and update it in a fast and friendly way. Such software is known as Advanced Planning and Scheduling Systems (APS). As highlighted by Ivert (2012), APS systems make the scheduling algorithms practical and more attractive.

The carrying out of criminal investigations and the preparation of forensic reports is precisely a situation in which the use of an APS software can offer a contribution. You never know when a crime will happen. The deadlines for delivering

the reports vary from case to case. The length of time a forensic scientist can perform can vary widely. Forensic personnel work on call. The number and variety of different reports to be allocated to each forensic scientist is very large. And lives are involved in this whole process (victims, accused, innocent, etc.). Although there is all this complexity, in practice the operations scheduling in FSS is done based only on priorities defined by the heads of the sections, manually or using electronic spreadsheets, without knowing if the scheduling will really bring better results in terms of dependability and better capacity utilization. That is, although there are improved management tools, in practice it is common to use methods that are not aligned with the evolution of knowledge (Bernardo *et al.*, 2022). With this, what happens are delays in the delivery of the reports and, consequently, a negative effect in the entire criminal investigation and criminal justice system, waste of public resources, in addition to the risk of violations of the human rights of those involved.

As Naves (2016) argues, the history of the Brazilian criminal area is marked by the distance between the academy and the knowledge construction process, which, in part, makes it difficult to validate scientific techniques, procedures and conclusions. Even though there is a noticeable gap, authors like Sala (2018) are emphatic when reporting that “at the institutional level, the most effective infrastructures must be developed in all areas of research, practice and politics”.

This is also corroborated by Santos *et al.* (2016) who state that “in the provision of public services, the growing demands of citizens to meet their needs and the need to rationalize public resources have forced governments through their public administration bodies to act more and more efficiently". Still, according to the same authors, FSS is one of the sectors with little attention paid by researchers in the area of operations management (Santos *et al.*, 2016), although it is a tool in the service of justice that uses science in favor of clarifying facts (Silva, 2019).

One of the improvement opportunities identified by the authors of the present work is to employ sequencing rules or operations scheduling algorithms for the allocation and realization of Forensic Science activities.

4 RESEARCH METHOD

The objective of the research is to apply algorithms of an APS software and to compare the results obtained by the software with the results and scheduling obtained previously.

To achieve the proposed objective, the case study method was applied. The case study is appropriate for the present study since it is a way of doing empirical social research, with the objective of investigating the phenomenon within its context. For Yin (1990), case studies are suitable for opportunities such as those in the present study. For this research, we chose to use the case study as a means of exploring the results that would be obtained in a practical situation in which the peculiarities are complex and, in addition, there was no clarity about the results that would be achieved. Among the disadvantages of the case study are the difficulty of generalization and the subjective nature of the measurement process. In the present study, however, it is not intended to generalize the results; only, from the primary sources, understand the phenomenon through the perspective of the object of study. In order to circumvent the subjective nature of the measurement of results, only analyzes of the reports obtained directly from the software were performed.

The composition of the case study was based on the propositions of Yin (1990), Meredith (1998) and Miguel (2007). First, a theoretical framework was built based on a literature review. Then the research question was elaborated. With regard to the guiding propositions, bearing in mind that these should help to focus attention on essential data (Yin, 1990), it was determined that the historical data of entry, allocation and deliveries of the FSS reports of a criminalistics technical section. With the previous proposition, the definition of the unit of analysis is clearly determined. Finally, the researchers decided not to elaborate a data collection protocol, as the necessary data would be collected directly from the information system of the Forensic Science unity.

All information related to the forensic science activities was obtained directly from the Regional Technical Section of Criminalistics, located at Avenida Deputado Renato Azeredo, n. 1342, in the city of Três Corações, Minas Gerais state, Brazil.

The sources of information were basically spreadsheets stored on the unit's computers and also in written records in books. The information is:

a) reference times (standards) for carrying out forensic science reports (Annex A);

b) shift schedule for the month of March 2015 (Annex B);

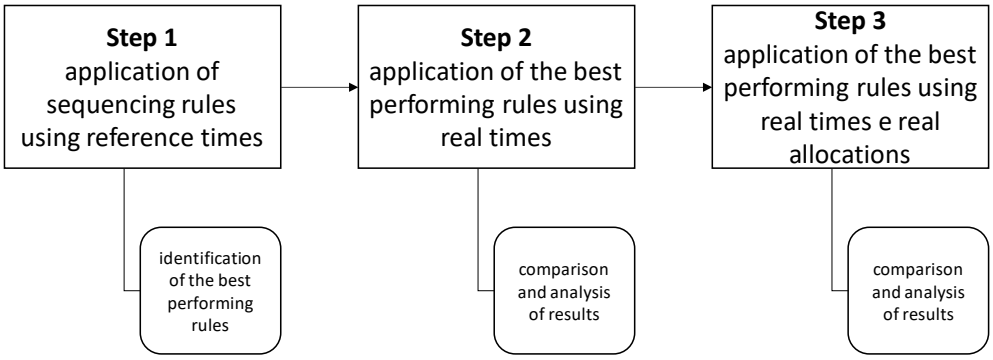
c) registration of forensic science examinations carried out in 2015.

It is important to highlight that the 2015 information was selected because it is the most recent available in spreadsheet format. Information from later years (from 2016 on) was recorded only in the official program of the Civilian Police of Minas Gerais, called PCNET. This system is a typical transactional system for recording requests for reports, codes, nature of exams, requesting units, dates (requisition, acceptance, forwarding, dispatch, etc.), assigned forensic scientist etc.

The research was carried out in three steps. The first step consisted of applying the sequencing rules available in the Preactor software using the reference times established by the Superintendence of Technical-Scientific Police of the Civilian Police from Minas Gerais state. The standard times for FSS reports are in the Annex A and details of the rules are described in the case study section. Sequencing results and resulting times were obtained from the software. With this step it was possible to verify the best rules for the problem studied. The second step was to apply only the rules with the best results from the previous step, now using the real times of the reports performed. The real times were obtained from the information system of the criminalistic technical section. In the third step, both real times and forensic scientist allocations carried out during the analyzed period were modeled in the software. From this modeling, the same previous sequencing rules (steps 2 and 3) were applied. In each of the steps, the average completion times of the activities, the forensic scientist allocations carried out (similarities and differences between rules and between the rules and real allocations) and the total number of reports carried out were analyzed.

Figure 1 below summarizes the research steps.

Figure 1 – Research steps



Source: Authors.

The replication of this research requires that the same software and version be used so that the results are compatible.

5 CASE STUDY

5.1 Encoding of information in the software

The information obtained was encoded in the Preactor® software, as follows:

- the forensic scientists were registered as primary resources with the following properties: “Finite Mode Behavior” Infinite with Shift, “Behavior in Infinite Mode” Infinite and “Efficiency” 100%. The forensic scientists were registered as infinite resources because the number of reports attributed to each of them cannot be limited, which, according to the data collected, is confirmed by the large number of reports attributed to the same forensic scientist over time;

- the FSS reports were registered as products without operating times. It was decided not to allocate operating times in the register so that when the reports was included as demands (orders in the software) it was possible to input the time according to the purpose of the analysis. To analyze the real results, the real times were included and to analyze the theoretical results, the standard times were include. Table 1 below summarizes the information from the registered FSS reports;

Table 1 – registration of FSS reports in the Preactor® software

Code	Product	Op. No.	Operation
001	Melee weapon	10	melee weapon forensic report
002	Fire gun	10	fire gun forensic report
003	Break-in	10	break-in forensic report
004	Indirect Evaluation	10	indirect evaluation forensic report
005	Explosive finding	10	explosive finding forensic report
006	Documentscopy	10	documentscopy forensic report
007	Dead bodies found	10	dead bodies found forensic report
008	Theft	10	theft forensic report
009	Graphotechnical	10	graphotechnical forensic report
010	Murder	10	murder forensic report
011	Fire	10	fire forensic report
012	Computing	10	Computing forensic report
013	Environment	10	environmental forensic report
014	Metallographic	10	metallographic forensic report
015	Patrimony	10	patrimony forensic report
016	Residuographic	10	residuographic forensic report
017	Toxic	10	toxic forensic report
018	Traffic with Victim	10	traffic with victim forensic report
019	Traffic without Victim	10	traffic without victim forensic report
020	Vehicle Inspection	10	vehicle inspection forensic report
021	Inspection at CCV site	10	inspection at ccv site forensic report

Source: Authors.

- the reference times (standards) for carrying out FSS reports were used to include the order times when analyzing the theoretical results in "Operation Times ...", "Time per item";

- shifts were registered as a “Primary Calendar Standard” and assigned to each forensic scientist;

- the forensic reports carried out were registered as orders with the following properties: In “Order No.” the number of the report was informed, in “Code” and “Product” the respective FSS report and in “Earlier Start Date” the date of entry of the service demand. For forensic examinations with an entry date prior to the month of March, the first day of March of two thousand and fifteen was assigned as the earliest start date. In "Resources ..." and "Times of Operation ..." the data were inserted according to the analysis that was intended to be carried out. The remaining properties were maintained according to the software's default as they did not interfere with the analyzes to be performed.

The researchers chose the month of March 2015 to carry out the study because it is the month with the highest total number of recorded services.

5.2 Application of software and verification of solutions

The researchers used the software to assess how forensic scientists reports would be scheduled using the algorithms present in the software. Two hundred and nine FSS reports were registered (Appendix 1).

5.2.1 FSS reports scheduling using reference times

First, it was verified how the forensic scientists' schedule would made in the month of March 2015 through the use of the software using the reference times (standards) established by the Superintendence of Technical-Scientific Police of the Civilian Police from Minas Gerais state. FSS reports were registered as orders with the same entry dates (in the software defined by the earlier start dates) and the processing times equal to the reference times (in the software defined by the operating time, time per item, in the orders window). All the APS rules available in Preactor® were used to generate the schedules, namely, the APS Forwards rule, the APS Backwards rule, the APS Parallel Loading rule and the APS Preferred Sequence rule. The APS Forwards rule sequences all operations forward, and subsequently, the last operation is blocked and all previous operations are sequenced backwards. The APS Backwards rule sequences operations backwards from the delivery date, and subsequently, the first operation is blocked and subsequent operations are sequenced forward. The APS Paralell Loading rule sequences operations based on simulation considering the availability of resources. And the APS Preferred Sequence rule sequences operations based on attributes (color, flavor, package size, product family) of the products or the operations themselves. For each of the rules used, the results were obtained through the statistics of the schedules and reports of the schedules.

5.2.2 FSS reports scheduling using real times

After testing the different rules, it was concluded that the rules with the best overall results were the APS Forwards and APS Backwards. So, the next step was to see how the results would look if the same rules were applied and the times were the same as the real times (and no longer the reference times). For this, the forensic

reports were registered as orders with the same start dates and the processing times equal to the real times.

In a first attempt to enter data, carried out only by changing the times in the schedule itself, that is, with the schedule already defined by Preactor®, the times of each order were changed one by one. As a result, many forensic reports was no longer allocated due to the lack of resources (insufficient capacity). For each order that was no longer allocated, the software presented the following warning: “Alert: Record “X” does not adjust to the available time of Resource “Y””. For this reason, after the end of the modification of the times (exchange of reference times for real times), all the forensic reports were deprogrammed and then reprogrammed with the same previous rule (in this first case, the APS Forwards rule). Statistics and result reports were collected and it was found that there were changes in relation to the initial schedule.

As it was found that the insertion of real times in the previous schedule (programming with reference times) causes the deprogramming of the forensic reports due to lack of capacity (which was verified in the case of the APS Forwards rule), for the APS Backwards rule the insertion of real times was performed prior to scheduling. Statistics and result reports were collected and it was found that there were changes in relation to the initial schedule.

5.2.3 Real forensic reports scheduling

The third application of the software and verification of the solutions was carried out as follows: in Preactor®, the real allocation for the month of March 2015 was implemented. The FSS reports were registered as orders with the same start dates (in the software defined by the earlier start dates) and the same allocation of forensic scientists (in the software defined by the required resource). In addition, the processing times were recorded according to the real times (in the software defined by the time of operation, time per item, in the order window). To generate the schedule, the APS Forwards and APS Backwards rules were used. Statistics and reports were collected.

5.3 Comparison of results

5.3.1 Comparison of rules using reference times

According to the statistics collected, the APS Forwards, APS Parallel Loading and APS Preferred Sequence rules generated very similar results. The APS Backwards rule generated slightly different results. In terms of the quality of allocations, there was a technical tie between the APS Forwards, APS Parallel Loading and APS Preferred Sequence rules and a small advantage of the APS Backwards rule over the others because the number of incomplete activities was less.

In an electronic spreadsheet, the differences between the end dates and the start dates of each FSS report were calculated. Then, the average values were calculated for each rule. The APS Forwards, APS Backwards, APS Parallel Loading and APS Preferred Sequence rules resulted in average times equal to 9:54:26, 10:46:30, 14:31:11 and 13:21:40 (hour:minute:second), respectively.

Each rule was compared in terms of forensic scientist allocation for each report. Table 2 summarizes the similarities between forensic scientist allocations in relation to each pair of rules.

Table 2 – percentage of similarity between each pair of rules in relation to the allocation of forensic reports to forensic scientist

	APS Forwards	**APS Backwards**	**APS Parallel Loading**	**APS Preferred Sequence**
APS Forwards	-	5.7%	78.9%	93.8%
APS Backwards	5.7%	-	7.7%	5.3%
APS Parallel Loading	78.9%	7.7%	-	84.7%
APS Preferred Sequence	93.8%	5.3%	84.7%	-

Source: Authors.

5.3.2 Comparison of rules using real time

According to the statistics collected, the APS Forwards rule with real times resulted in 20 reports unallocated while the APS Backwards rule resulted in only one. The other statistical results are similar or with differences that do not represent superiority or inferiority of one in relation to the other.

Reports numbers 540, 577, 597, 601, 602, 603, 604, 605, 606, 607, 608, 609, 610, 611, 612, 613, 638, 640, 642 and 643 were not allocated by the APS Forwards rule due to the lack of resources capacity. Report 388 was not allocated under the APS Backwards rule due to lack of resources.

In an electronic spreadsheet, the differences between the end dates and the start dates of each report were calculated. Then, the average values were calculated for each rule. The APS Forwards and APS Backwards rules resulted in average times equal to 93:46:11 and 105:07:36, respectively.

Among the APS Forwards and APS Backwards rules the only reports that had the same allocated forensic scientists were: 078, 081, 096, 142, 148, 291, 292, 293, 294, 389, 394, 401, 416, 483, 493, 496, 497, 503, 504, 505, 506, 507, 508, 509, 512, 513, 551, 552, 565, 575 and 576. The remaining reports were allocated to different forensic scientists. All of the forensic scientists' start and end dates were different between these two rules, except for number 483.

5.3.3 Comparison of rules using real times and real allocation

As per the statistics collected, the APS Forwards rule with real allocation resulted in 25 reports not being allocated while the APS Backwards rule with real allocation resulted in 3 unallocated. The other statistical results are similar or with differences that do not represent superiority or inferiority of one in relation to the other.

In an electronic spreadsheet, the differences between the end dates and the start dates of each report were calculated. Then, the average values were calculated for each rule. The APS Forwards and APS Backwards rules with real times resulted in average times equal to 93:46:11 and 105:07:36, respectively. The APS Forwards and APS Backwards rules with real allocation resulted in average times equal to 101:50:03 and 124:42:05, respectively.

In a spreadsheet, the differences between the end dates and the earlier start dates of each report were calculated, that is, the flow times. Then, the mean values for each rule were calculated, that is, the mean flow times. For this comparison, only the reports that were allocated by all rules was considered. Under these conditions, the APS Forwards rule with real times, APS Forwards with real allocations, APS

Backwards with real times, APS Backwards with real allocations resulted in average flow times equal to 91:27:42, 114:55:03, 457:56:04 and 419:28:31. The real allocation, considering the same reports, has an average flow time of 101:55:54.

Table 3 summarizes the similarities between FSS reports allocations to forensic scientists in relation to each pair of rules.

Table 3 – percentage of similarity between each pair of rules in relation to the FSS reports allocation to forensic scientists

	APS Forwards real allocation	**APS Backwards real allocation**
APS Forwards real time	26.3%	27.3%
APS Backwards real time	15.3%	22.0%

Source: Authors.

5.3.4 Summary of comparisons between rules

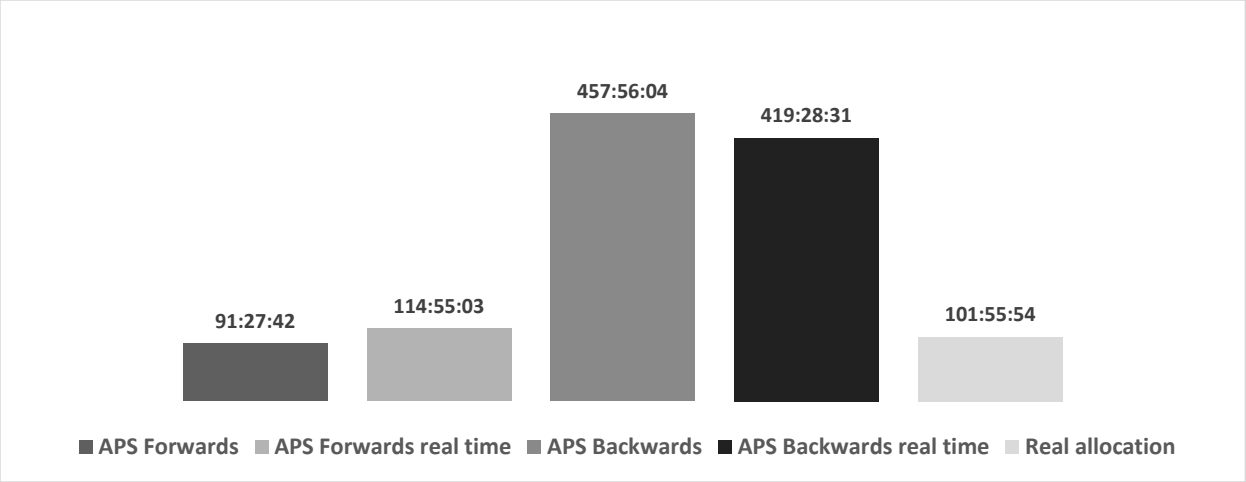
Using the reference times, the APS Forwards and APS Backwards rules presented the best results in terms of scheduling statistics and scheduling reports generated by the software itself and also in relation to the average times of the differences between the end dates and the start dates of each report. As a result, these two rules were used to make comparisons between the results that would be obtained with the real times.

Using real time, the APS Forwards rule resulted in a greater number of unallocated reports due to lack of capacity (9.57% non-allocation) compared to the APS Backwards rule (0.48% non-allocation). Regarding the average times of the differences between the end dates and the start dates of each report, the APS Forwards rule resulted in a lower value, equivalent to about 90% of the average time of the APS Backwards rule.

The reports were also inserted in the software with the real allocation, that is, in addition to the real times, the reports were allocated to the forensic personnel according to the historical record. For these allocations, the APS Forwards rule resulted in a greater number of unallocated reports due to lack of capacity (11.96% non-allocation) compared to the APS Backwards rule (1.44% non-allocation). Regarding the average times of the differences between the end dates and the start dates of each report, the APS Forwards rule resulted in a lower value, equivalent to

about 82% of the average time of the APS Backwards rule. Comparing the average flow times, the only rule with a lower result in relation to the real allocation was the APS Forwards rule, with about 90% of the average flow time of the latter. The graph in figure 2 summarizes the average flow times of the rules.

Figure 2 – Average flow time of the rules



Source: Authors.

Regarding the comparison between the rules using reference times with respect to the allocation of reports to forensic personnel, the results showed a similarity of 5.7% between the rules APS Forwards and APS Backwards, 78.9% between the rules APS Forwards and APS Parallel Loading, 93.8% between APS Forwards and APS Preferred Sequence rules, 7.7% between APS Backwards and APS Parallel Loading rules, 5.3% between APS Backwards and APS Preferred Sequence rules and 84.7% between rules APS Parallel Loading and APS Preferred Sequence.

Regarding the comparison between the rules using real times with respect to the allocation of reports to forensic scientists, the results showed a similarity of 14.83% between the rules APS Forwards and APS Backwards.

Regarding the comparison between the rules using real times and the real allocation with respect to the allocation of reports to forensic scientists, the results showed a similarity of 26.3% between the APS Forwards rule with real times and

APS Forwards with real allocation, 22% between APS Backwards rule with real time and APS Backwards with real allocation, 27.3% between APS Forwards rule with real time and APS Backwards with real allocation, 15.3% between APS Backwards rule with real time and APS Forwards with real allocation.

5.3.5 Conclusions on comparisons between rules and discussion

From the results obtained, it can be concluded that the scheduling performed from the software's internal algorithms are, at the same time, different and better than the real scheduling performed manually by the head of the section. The similarities obtained from the algorithms in relation to the real allocation ranged between 15.3% and 27.3%. The best result obtained by the algorithm in terms of average flow time showed a reduction of about 10% in relation to the real scheduling.

Regarding the scheduling carried out by the software, it is concluded that the APS Forwards and APS Backwards rules were the ones that presented the best results (in relation to the results given by the APS Parallel Loading and APS Preferred Sequence rules).

In the day-to-day practice of the sector, scheduling is performed manually and based on the head of the section’s experience and also based on simple rules like FIFO or EDD. Scheduling through the APS software uses internal algorithms that provide a different schedule in relation to the allocation of resources and in relation to the beginnings and endings of tasks compared to what is done in practice. These differences have been shown to improve results in terms of the time needed to complete and, consequently, meet due dates. Thus, it can be concluded that obtaining superior results is not intuitive and would hardly be achieved only based on the experience of the decision maker. The results of the present study corroborate that the use of simple rules such as FIFO and EDD does not necessarily offer the best results in practical and complex situations.

As this is a public service that has notably difficulties in meeting due dates, these results are encouraging as they indicate a possible path to be followed to improve the use of public resources, better meet demand and more effectively comply with service to society.

It can also be said that the user-friendly interface and use of the software, through prior training of users, can make the scheduling of forensic scientists' tasks more efficient at Forensic Science unities. It can also free up more time for the decision maker to solve other day-to-day issues.

Finally, it is noted that the difficulties faced in using the software in this case studied were few and, therefore, did not prevent its proper use in this service and shows that an adaptation or reformulation of the software is not necessary to start your application.

5.4 Capacity analysis

The use of the software demonstrated that the capacity of the Regional Technical Section of Criminalistics of Três Corações is exceeded during some periods. The number of reports not scheduled by the software varied according to the rule used, ranging from one to twenty-five not allocated.

The same finding can be made from the actual allocation given by the unit's record history. Some reports took several months to complete and were carried out in parallel with many other reports by the same forensic scientist.

6 FINAL CONSIDERATIONS

Operations scheduling in Forensic Science services, although notably a difficult task, is usually not carried out with the aid of APS-type systems. However, the complexity and dynamism of this activity suggests precisely the use of software to aid decision making (Enns, 1996). The results of the detailed research in this article provide insights into using an APS software in this situation not yet explored in the literature.

The implementation of the reports in the Preactor® software proved to be feasible and reasonably easy considering the simplification already used by the Technical-Scientific Police Superintendence in relation to the gathering of all types of reports in only 13 groups (according to Annex A) with standards times for each group.

The results show that scheduling and rescheduling from the software's algorithms can bring better results than those currently achieved. These better results are related to the average flow time of the reports (disregarding the reports that was not allocated due to lack of capacity). As developing a system for allocating reports to forensic scientists would take considerable time (Nguyen *et al.*, 2017) and would also require considerable investments, these results weigh in favor of choosing to use ready-made software already available on the market. As the results show that the reports flow times were, on average, shorter than the times in real allocations, it can be said that the allocations suggested by the software can bring benefits to the operation. The benefits would be, firstly, to greater responsiveness of the operation and, secondly, to the increase in the number of reports carried out by the same forensic scientists who are currently in the studied STRC. Thus, as stated by Fuchigami and Rangel (2018), the use of computer systems aimed at operations scheduling can increase the practical application of research in the area.

The biggest difficulty for working with the software during the research, which would probably be similar to the case of practical use in the Regional Technical Section of Criminalistics of Três Corações, is registering the shifts of forensic scientists in specific calendars. Also, in practical use it would be necessary for this registration to be done manually month by month, since the shift schedule is defined by month and changes every month.

The analysis of only one group of historical data is the main limitation of the present work. Thus, studies covering longer time horizons could complement the results found here. Other future research that could add conclusions to the present work would be an evaluation of the same rules using average real times from recent years instead of real times collected from just one historical period.

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ANNEX A - Standard times for Forensic Science reports
The following times are recorded in an official document written by the Superintendence of the Technical and Scientific Police of the State of Minas Gerais/BRA, in March 2010.

Forensic medicine
Evaluation in living person = 35 minutes;
Evaluation dead person = 210 minutes.

Forensic Criminalistic
- Life forensic report = 24 hours;
- Traffic forensic report = 18 hours;
- Patrimony forensic report = 10 hours;
- Evaluation report = 1 hour;
- Environment forensic report = 16 hours;
- Legal Engineering forensic report = 16 hours;
- Audio, Video and Computer forensic report = 3 hours;
- Ballistics/Efficiency forensic report = 3 hours;
- Documentscopy forensic report = 4 hours;
- Toxiclogical finding forensic report = 0.5 hour;
- Other = 3 hours.

ANNEX B - March 2015, forensic scientists' shift schedule

Schedule	Sunday 03/01/15	Monday 03/02/15	Tuesday 03/03/15	Wednesday 03/04/15	Thursday 03/05/15	Friday 03/06/15	Saturday 03/07/15
1º shift (00:00 to 12:00)	Forensic Scientist 2	Forensic Scientist 6	Forensic Scientist 6	Forensic Scientist 6	Forensic Scientist 2	Forensic Scientist 2	Forensic Scientist 5
2º shift (12:00 to 00:00)	Forensic Scientist 3	Forensic Scientist 4	Forensic Scientist 3	Forensic Scientist 3	Forensic Scientist 5	Forensic Scientist 3	Forensic Scientist 4
Office hour (08:00 to 12:00)		Forensic Scientist 2	Forensic Scientist 2	Forensic Scientist 5	Forensic Scientist 6	Forensic Scientist 4	
Office hour (14:00 to 18:00)		Forensic Scientist 2	Forensic Scientist 2		Forensic Scientist 3		
Química (12:00 to 00:00)		Lab. Forensic Scientist	Lab. Forensic Scientist	Lab. Forensic Scientist	Lab. Forensic Scientist		

Schedule	Sunday 03/08/15	Monday 03/09/15	Tuesday 03/10/15	Wednesday 03/11/15	Thursday 03/12/15	Friday 03/13/15	Saturday 03/14/15
1º shift (00:00 to 12:00)	Forensic Scientist 5	Forensic Scientist 2	Forensic Scientist 6	Forensic Scientist 2	Forensic Scientist 3	Forensic Scientist 2	Forensic Scientist 4
2º shift (12:00 to 00:00)	Forensic Scientist 4	Forensic Scientist 4	Forensic Scientist 3	Forensic Scientist 5	Forensic Scientist 6	Forensic Scientist 6	Forensic Scientist 5
Office hour (08:00 to 12:00)		Forensic Scientist 6		Forensic Scientist 3	Forensic Scientist 2	Forensic Scientist 3	
Office hour (14:00 to 18:00)		Forensic Scientist 5	Forensic Scientist 4	Forensic Scientist 3		Forensic Scientist 3	
Chemistry (12:00 to 00:00)		Lab. Forensic Scientist	Lab. Forensic Scientist	Lab. Forensic Scientist	Lab. Forensic Scientist		

Schedule	Sunday 03/15/15	Monday 03/16/15	Tuesday 03/17/15	Wednesday 03/18/15	Thursday 03/19/15	Friday 03/20/15	Saturday 03/21/15
1º shift (00:00 to 12:00)	Forensic Scientist 4	Forensic Scientist 6	Forensic Scientist 5	Forensic Scientist 3	Forensic Scientist 3	Forensic Scientist 3	Forensic Scientist 1
2º shift (12:00 to 00:00)	Forensic Scientist 5	Forensic Scientist 4	Forensic Scientist 4	Forensic Scientist 5	Forensic Scientist 5	Forensic Scientist 4	Forensic Scientist 6
Office hour (08:00 to 12:00)		Forensic Scientist 1		Forensic Scientist 6	Forensic Scientist 1	Forensic Scientist 5	
Office hour (14:00 to 18:00)		Forensic Scientist 1	Forensic Scientist 3	Forensic Scientist 4	Forensic Scientist 1		
Chemistry (12:00 to		Lab. Forensic	Lab. Forensic	Lab. Forensic	Lab. Forensic		

00:00)		Scientist	Scientist	Scientist	Scientist		

Schedule	Sunday 03/22/15	Monday 03/23/15	Tuesday 03/24/15	Wednesday 03/25/15	Thursday 03/26/15	Friday 03/27/15	Saturday 03/28/15
1º shift (00:00 to 12:00)	Forensic Scientist 1	Forensic Scientist 1	Forensic Scientist 5	Forensic Scientist 5	Forensic Scientist 5	Forensic Scientist 3	Forensic Scientist 6
2º shift (12:00 to 00:00)	Forensic Scientist 6	Forensic Scientist 4	Forensic Scientist 4	Forensic Scientist 3	Forensic Scientist 6	Forensic Scientist 4	Forensic Scientist 1
Office hour (08:00 to 12:00)		Forensic Scientist 5	Forensic Scientist 3	Forensic Scientist 1	Forensic Scientist 3		
Office hour (14:00 to 18:00)		Forensic Scientist 3	Forensic Scientist 3	Forensic Scientist 6	Forensic Scientist 4		
Chemistry (12:00 to 00:00)					Lab. Forensic Scientist	Lab. Forensic Scientist	

Schedule	Sunday 03/29/15	Monday 03/30/15	Tuesday 03/31/15				
1º shift (00:00 to 12:00)	Forensic Scientist 6	Forensic Scientist 5	Forensic Scientist 6				
2º shift (12:00 to 00:00)	Forensic Scientist 1	Forensic Scientist 4	Forensic Scientist 1				
Office hour (08:00 to 12:00)		Forensic Scientist 1					
Office hour (14:00 to 18:00)		Forensic Scientist 3	Forensic Scientist 5				
Chemistry (12:00 to 00:00)		Lab. Forensic Scientist	Lab. Forensic Scientist				

APPENDIX 1 - Registered forensic scientists' reports

Order No.	Product	Part No.	Qty.	Op. No.	Operation Name
007	Theft	008	1	10	Theft forensic report
008	Inspection at CCV site	021	1	10	Inspection at CCV site forensic report
022	Traffic with victim	018	1	10	Traffic with victim forensic report
048	Traffic without victim	019	1	10	Traffic without victim forensic report
078	Traffic without victim	019	1	10	Traffic without victim forensic report
081	Traffic without victim	019	1	10	Traffic without victim forensic report
096	Environment	013	1	10	Environment forensic report
126	Patrimony	015	1	10	Patrimony forensic report
133	Cumputing	012	1	10	Cumputing forensic report
134	Cumputing	012	1	10	Cumputing forensic report
135	Cumputing	012	1	10	Cumputing forensic report
137	Dead bodies found	007	1	10	Dead bodies found forensic report
142	Patrimony	015	1	10	Patrimony forensic report
148	Traffic without victim	019	1	10	Traffic without victim forensic report
151	Fire gun	002	1	10	Fire gun forensic report
157	Fire gun	002	1	10	Fire gun forensic report
158	Fire gun	002	1	10	Fire gun forensic report
159	Fire gun	002	1	10	Fire gun forensic report
194	Traffic with victim	018	1	10	Traffic with victim forensic report
201	Environment	013	1	10	Environment forensic report
202	Environment	013	1	10	Environment forensic report
203	Environment	013	1	10	Environment forensic report
225	Cumputing	012	1	10	Cumputing forensic report
234	Dead bodies found	007	1	10	Dead bodies found forensic report
237	Patrimony	015	1	10	Patrimony forensic report
246	Traffic without victim	019	1	10	Traffic without victim forensic report
250	Traffic without victim	019	1	10	Traffic without victim forensic report
258	Patrimony	015	1	10	Patrimony forensic report
272	Murder	010	1	10	Murder forensic report
291	Patrimony	015	1	10	Patrimony forensic report
292	Patrimony	015	1	10	Patrimony forensic report
293	Toxic	017	1	10	Toxic forensic report
294	Patrimony	015	1	10	Patrimony forensic report
307	Patrimony	015	1	10	Patrimony forensic report
308	Melee weapon	001	1	10	Melee weapon forensic report

351	Patrimony	015	1	10	Patrimony forensic report
352	Patrimony	015	1	10	Patrimony forensic report
374	Break-in	003	1	10	Break-in forensic report
376	Melee weapon	001	1	10	Melee weapon forensic report
377	Melee weapon	001	1	10	Melee weapon forensic report
381	Indirect evaluation	004	1	10	Indirect evaluation forensic report
382	Fire	011	1	10	Fire forensic report
384	Cumputing	012	1	10	Cumputing forensic report
385	Cumputing	012	1	10	Cumputing forensic report
386	Cumputing	012	1	10	Cumputing forensic report
388	Traffic without victim	019	1	10	Traffic without victim forensic report
389	Patrimony	015	1	10	Patrimony forensic report
390	Toxic	017	1	10	Toxic forensic report
391	Toxic	017	1	10	Toxic forensic report
392	Traffic without victim	019	1	10	Traffic without victim forensic report
393	Break-in	003	1	10	Break-in forensic report
394	Break-in	003	1	10	Break-in forensic report
395	Graphotechnical	009	1	10	Graphotechnical forensic report
399	Patrimony	015	1	10	Patrimony forensic report
401	Patrimony	015	1	10	Patrimony forensic report
402	Patrimony	015	1	10	Patrimony forensic report
404	Metallographic	014	1	10	Metallographic forensic report
405	Melee weapon	001	1	10	Melee weapon forensic report
406	Indirect Evaluation	004	1	10	Indirect evaluation forensic report
407	Traffic without victim	019	1	10	Traffic without victim forensic report
408	Fire gun	002	1	10	Fire gun forensic report
409	Fire gun	002	1	10	Fire gun forensic report
410	Fire gun	002	1	10	Fire gun forensic report
411	Fire gun	002	1	10	Fire gun forensic report
412	Fire gun	002	1	10	Fire gun forensic report
413	Toxic	017	1	10	Toxic forensic report
414	Explosive finding	005	1	10	Explosive finding forensic report
415	Explosive finding	005	1	10	Explosive finding forensic report
416	Vehicle inspection	020	1	10	Vehicle inspection forensic report
417	Fire gun	002	1	10	Fire gun forensic report
418	Fire gun	002	1	10	Fire gun forensic report
420	Toxic	017	1	10	Toxic forensic report
421	Toxic	017	1	10	Toxic forensic report
422	Toxic	017	1	10	Toxic forensic report
423	Toxic	017	1	10	Toxic forensic report
424	Toxic	017	1	10	Toxic forensic report

425	Traffic without victim	019	1	10	Traffic without victim forensic report
426	Fire gun	002	1	10	Fire gun forensic report
427	Fire gun	002	1	10	Fire gun forensic report
428	Fire gun	002	1	10	Fire gun forensic report
429	Fire gun	002	1	10	Fire gun forensic report
430	Fire gun	002	1	10	Fire gun forensic report
431	Fire gun	002	1	10	Fire gun forensic report
432	Fire gun	002	1	10	Fire gun forensic report
433	Patrimony	015	1	10	Patrimony forensic report
435	Toxic	017	1	10	Toxic forensic report
436	Residuographic	016	1	10	Residuographic forensic report
437	Fire gun	002	1	10	Fire gun forensic report
438	Fire gun	002	1	10	Fire gun forensic report
439	Fire gun	002	1	10	Fire gun forensic report
440	Fire gun	002	1	10	Fire gun forensic report
442	Melee weapon	001	1	10	Melee weapon forensic report
443	Melee weapon	001	1	10	Melee weapon forensic report
444	Toxic	017	1	10	Toxic forensic report
466	Cumputing	012	1	10	Cumputing forensic report
467	Cumputing	012	1	10	Cumputing forensic report
468	Melee weapon	001	1	10	Melee weapon forensic report
483	Patrimony	015	1	10	Patrimony forensic report
484	Patrimony	015	1	10	Patrimony forensic report
487	Indirect Evaluation	004	1	10	Indirect evaluation forensic report
490	Toxic	017	1	10	Toxic forensic report
492	Patrimony	015	1	10	Patrimony forensic report
493	Patrimony	015	1	10	Patrimony forensic report
495	Indirect Evaluation	004	1	10	Indirect evaluation forensic report
496	Fire	011	1	10	Fire forensic report
497	Fire	011	1	10	Fire forensic report
498	Toxic	017	1	10	Toxic forensic report
499	Toxic	017	1	10	Toxic forensic report
500	Fire gun	002	1	10	Fire gun forensic report
501	Toxic	017	1	10	Toxic forensic report
502	Traffic without victim	019	1	10	Traffic without victim forensic report
503	Traffic without victim	019	1	10	Traffic without victim forensic report
504	Patrimony	015	1	10	Patrimony forensic report
505	Toxic	017	1	10	Toxic forensic report
506	Toxic	017	1	10	Toxic forensic report
507	Fire gun	002	1	10	Fire gun forensic report
508	Toxic	017	1	10	Toxic forensic report

509	Toxic	017	1	10	Toxic forensic report
510	Traffic without victim	019	1	10	Traffic without victim forensic report
511	Patrimony	015	1	10	Patrimony forensic report
512	Toxic	017	1	10	Toxic forensic report
513	Melee weapon	001	1	10	Melee weapon forensic report
517	Toxic	017	1	10	Toxic forensic report
518	Toxic	017	1	10	Toxic forensic report
519	Toxic	017	1	10	Toxic forensic report
520	Toxic	017	1	10	Toxic forensic report
521	Toxic	017	1	10	Toxic forensic report
522	Toxic	017	1	10	Toxic forensic report
523	Toxic	017	1	10	Toxic forensic report
524	Patrimony	015	1	10	Patrimony forensic report
525	Patrimony	015	1	10	Patrimony forensic report
528	Patrimony	015	1	10	Patrimony forensic report
534	Patrimony	015	1	10	Patrimony forensic report
535	Fire gun	002	1	10	Fire gun forensic report
537	Environment	013	1	10	Environment forensic report
540	Environment	013	1	10	Environment forensic report
541	Environment	013	1	10	Environment forensic report
542	Environment	013	1	10	Environment forensic report
544	Environment	013	1	10	Environment forensic report
545	Vehicle inspection	020	1	10	Vehicle inspection forensic report
548	Patrimony	015	1	10	Patrimony forensic report
549	Toxic	017	1	10	Toxic forensic report
550	Toxic	017	1	10	Toxic forensic report
551	Murder	010	1	10	Murder forensic report
552	Patrimony	015	1	10	Patrimony forensic report
555	Melee weapon	001	1	10	Melee weapon forensic report
557	Traffic without victim	019	1	10	Traffic without victim forensic report
558	Toxic	017	1	10	Toxic forensic report
559	Toxic	017	1	10	Toxic forensic report
560	Toxic	017	1	10	Toxic forensic report
561	Toxic	017	1	10	Toxic forensic report
562	Toxic	017	1	10	Toxic forensic report
563	Traffic without victim	019	1	10	Traffic without victim forensic report
564	Traffic without victim	019	1	10	Traffic without victim forensic report
565	Environment	013	1	10	Environment forensic report
566	Toxic	017	1	10	Toxic forensic report
567	Toxic	017	1	10	Toxic forensic report

568	Melee weapon	001	1	10	Melee weapon forensic report
571	Toxic	017	1	10	Toxic forensic report
572	Indirect Evaluation	004	1	10	Indirect evaluation forensic report
573	Indirect Evaluation	004	1	10	Indirect evaluation forensic report
574	Documentscpopy	006	1	10	Documentscpopy forensic report
575	Patrimony	015	1	10	Patrimony forensic report
576	Traffic without victim	019	1	10	Traffic without victim forensic report
577	Fire gun	002	1	10	Fire gun forensic report
581	Patrimony	015	1	10	Patrimony forensic report
584	Indirect Evaluation	004	1	10	Indirect evaluation forensic report
586	Indirect Evaluation	004	1	10	Indirect evaluation forensic report
587	Fire gun	002	1	10	Fire gun forensic report
588	Fire gun	002	1	10	Fire gun forensic report
590	Fire gun	002	1	10	Fire gun forensic report
591	Fire gun	002	1	10	Fire gun forensic report
592	Fire gun	002	1	10	Fire gun forensic report
593	Fire gun	002	1	10	Fire gun forensic report
594	Fire gun	002	1	10	Fire gun forensic report
595	Fire gun	002	1	10	Fire gun forensic report
596	Dead bodies found	007	1	10	Dead bodies found forensic report
597	Traffic without victim	019	1	10	Traffic without victim forensic report
598	Toxic	017	1	10	Toxic forensic report
599	Cumputing	012	1	10	Cumputing forensic report
601	Fire gun	002	1	10	Fire gun forensic report
602	Fire gun	002	1	10	Fire gun forensic report
603	Fire gun	002	1	10	Fire gun forensic report
604	Fire gun	002	1	10	Fire gun forensic report
605	Fire gun	002	1	10	Fire gun forensic report
606	Fire gun	002	1	10	Fire gun forensic report
607	Fire gun	002	1	10	Fire gun forensic report
608	Fire gun	002	1	10	Fire gun forensic report
609	Fire gun	002	1	10	Fire gun forensic report
610	Fire gun	002	1	10	Fire gun forensic report
611	Fire gun	002	1	10	Fire gun forensic report
612	Fire gun	002	1	10	Fire gun forensic report
613	Fire gun	002	1	10	Fire gun forensic report
614	Melee weapon	001	1	10	Melee weapon forensic report
615	Melee weapon	001	1	10	Melee weapon forensic report
629	Patrimony	015	1	10	Patrimony forensic report
630	Melee weapon	001	1	10	Melee weapon forensic report
631	Melee weapon	001	1	10	Melee weapon forensic report

632	Toxic	017	1	10	Toxic forensic report
633	Fire gun	002	1	10	Fire gun forensic report
634	Fire gun	002	1	10	Fire gun forensic report
635	Melee weapon	001	1	10	Melee weapon forensic report
636	Indirect Evaluation	004	1	10	Indirect evaluation forensic report
637	Melee weapon	001	1	10	Melee weapon forensic report
638	Traffic without victim	019	1	10	Traffic without victim forensic report
639	Toxic	017	1	10	Toxic forensic report
640	Patrimony	015	1	10	Patrimony forensic report
642	Melee weapon	001	1	10	Melee weapon forensic report
643	Vehicle inspection	020	1	10	Vehicle inspection forensic report