

Stochastic Simulation and Optimization of Human Resource Management Processes in Higher Education

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Abstract—The administration of human resources in Higher Education Institutions (HEIs) involves complex, multi-departmental workflows that are highly susceptible to fluctuations in demand. The objective of this paper is to evaluate the efficiency, cost, and resilience of selected academic HR processes under varying workloads and resource configurations. The study addresses the limited use of BPMN-based stochastic discrete-event simulation for diagnosing operational and cost bottlenecks in HEI and public-sector HR administration. Three critical academic HR processes are modeled: Employment, Ongoing HR Services, and Dismissal of academic teachers. Utilizing the Prosimos stochastic simulation engine via the AureaSim wrapper, we evaluated the current Business Process Model and Notation (BPMN) models against four operational scenarios: Baseline, Peak Load, Recovery Plan, and Cost Optimization. Simulation data (n=500 cases per process) reveal that baseline configurations are highly vulnerable to peak loads, with the cycle time for employment degrading from 5.08 days to over 385 days. Through hypothesis testing, we identified structural inefficiencies such as “scale bottlenecks” in routine tasks and “cost bottlenecks” in legal compliance. The contribution of the paper is a scenario-based simulation framework that links BPMN process models, stochastic parameters, and Activity-Based Costing to support evidence-based HR process redesign. The results suggest that targeted interventions, including document template standardization, selective automation, and workload-oriented resource allocation, can restore acceptable cycle times while controlling operational costs.

Index Terms—Management, Business Process Simulation, Human Resource Management, Higher Education, Prosimos, Discrete-Event Simulation, BPMN.

I. INTRODUCTION

HIGHER Education Institutions (HEIs) operate within complex, highly regulated frameworks that govern everything from academic research to administrative workflows. The Military University of Technology (WAT) in Warsaw, which serves as the primary case study for this research, represents a particularly unique organizational environment. Established in 1951, the university functions with a dual military-civilian profile. It combines the characteristics of a classic research

and teaching university with the rigorous, hierarchical structure of a military unit subordinate to the Ministry of National Defence [27].

The scale of operations within such an institution is vast, employing thousands of personnel, including professional soldiers, academic teachers, and civilian administrative and technical staff [24]. Because the university operates within the public finance and military sectors, it maintains an exceptionally high level of formalization [19]. Business processes are strictly regulated by internal legal acts and normative documents, which guarantees consistency and legal compliance. However, this rigorous formalization simultaneously breeds a massive risk of bureaucratization and the formation of severe organizational bottlenecks [20]. Human Resource (HR) departments in these environments are forced to manage workflows that require sequential, multi-stage approvals across various organizational levels. These levels often span from direct department heads to centralized administrative units like the Legal Support Section (SOP) and the Finance Department (KWE), up to executive Rectorate authorities (e.g., the Chancellor, Vice-Rectors, and the Rector) [23].

From the perspective of Business Process Management (BPM) engineering, this highly formalized environment serves as an excellent testing ground [2]. Identifying inefficiencies within such a rigid structure, backed by hard empirical data, allows for the formulation of highly valuable optimization strategies [21]. Therefore, this study departs from purely theoretical BPM considerations to analyze the actual organizational reality of a functioning HEI [12].

The primary objective of this research is to comprehensively map, model, and evaluate the efficiency, cost, and potential bottlenecks of critical academic HR processes under various operational conditions. To achieve this, we utilized Business Process Model and Notation (BPMN 2.0) to map the current “as-is” state of the organization based on official university procedures. However, to truly understand system performance, we eschewed static analysis in favor of stochastic discrete-event simulation (DES) [16]. By introducing random variables—such as exponential distributions for case arrival rates and normal

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distributions for task durations—we aim to quantitatively evaluate how varying workloads and resource allocations impact key performance indicators (KPIs), specifically average cycle time, resource wait times, and the Activity-Based Costing of specific administrative tasks [17].

To conduct this evaluation, we modeled three core HR processes that represent the critical lifecycle of an academic employee, governed by the institutional procedure "DPE/1":

- 1) **DPE 1.2: Employment of an academic teacher.** A highly complex process critical to the institution's didactic and scientific potential, requiring multi-tier executive sign-offs and extensive documentation [22].
- 2) **DPE 1.3: Ongoing HR services.** A high-volume, routine process encompassing daily administrative interactions, such as leave requests and contractual adjustments [18].
- 3) **DPE 1.5: Dismissal of an academic teacher.** A highly formalized procedure requiring strict legal compliance, union consultations, and extended clearance workflows.

Through the simulation of these distinct pathways, this paper provides actionable, data-driven insights into resource management, bottleneck mitigation, and the potential for digital transformation within public academic institutions [7], [8].

II. RELATED WORK

Business Process Management (BPM) provides a structured approach for identifying, modeling, analyzing, and improving organizational workflows. BPMN is widely used as a standard notation for representing process logic, roles, decision points, and handovers, while simulation extends static process models by enabling quantitative assessment of throughput, queues, resource utilization, and cost under uncertainty [1], [2]. In administrative environments, this dynamic perspective is particularly important because delays often emerge from interactions between workload variability, sequential approval paths, and constrained specialist resources rather than from the nominal process structure alone [20], [18].

Recent work has shown that BPMN-based modeling combined with discrete-event simulation can support process redesign in legally constrained public-sector settings. Studies of public administration demonstrate that simulation can test alternative staffing and workflow scenarios before organizational changes are implemented, helping to identify queue formation, capacity saturation, and cost implications [6]. Related research in business process improvement also emphasizes that process models, resource allocation, and operational constraints should be considered jointly when evaluating redesign options [5].

For HEIs, administrative efficiency is closely connected with service quality, compliance, and the effective use of academic and professional staff time. However, HR processes in universities remain less frequently examined with formal BPMN-based stochastic simulation than teaching, research, or student-service processes. Existing studies on process-oriented public organizations and document workflows indicate that formalized procedures can improve control, but may also create bottlenecks when documents circulate through many roles and approvals [19], [16], [11].

Digitalization, Employee Self-Service (ESS), and Robotic Process Automation (RPA) are often proposed as responses to repetitive administrative work. The RPA literature stresses that automation is most appropriate for high-volume, rule-based, and standardized tasks, especially where manual data entry or document generation consumes skilled labor [7], [8], [9]. Process mining provides a complementary validation path because event logs can be used to discover real execution patterns and compare them with modeled workflows [3], [10]. Against this background, the present study contributes a focused, scenario-based simulation of academic HR procedures, linking BPMN models, stochastic parameters, resource costs, and managerial hypotheses for a highly formalized university context.

III. METHODOLOGY

A. Process Mapping and BPMN Models

The foundation of this empirical study required an accurate representation of the "as-is" organizational state. The mapping was executed using the Business Process Model and Notation (BPMN 2.0) standard [20]. While BPMN provides an excellent structural overview of the sequential approvals, parallel gateways, and resource lanes involved in academic HR, a purely static analysis of these diagrams is insufficient for identifying system constraints under varying loads [18]. Therefore, static analysis was discarded in favor of dynamic evaluation through specialized software simulators [16].

B. Simulation Engine and Activity-Based Costing

To quantitatively evaluate the mapped processes, we employed Stochastic Discrete-Event Simulation (DES). The experiments were conducted using the *Aurea Sim* analytical package, a specialized Python wrapper that operates on the robust *Prosimos* simulation engine [26]. This environment allowed for the observation of process behavior over time, specifically enabling the calculation of queue waiting times and total cycle times (lead times) for individual cases [17].

A critical component of this methodology was the integration of Activity-Based Costing (ABC) [16]. To move beyond mere time-based efficiency metrics, exact hourly financial rates were assigned to the organizational resources defined in the simulation [17]. This enabled a granular financial valuation of every administrative task executed. The defined resource rates included, among others:

- **Competition Committee:** 300 PLN/h
- **Rector (RKR):** 250 PLN/h
- **Vice-Rectors (PRK/PRN):** 180 PLN/h
- **Hiring Manager:** 140 PLN/h
- **Personnel Department Specialist (DPE):** 60 PLN/h

C. Experimental Design and Stochastic Parameters

To ensure the simulation accurately reflected the legal conditions and actual administrative capabilities of the university, stochastic variables were rigorously parameterized [17]. For each of the three evaluated processes, a sample size of 500 process instances was simulated to guarantee statistical

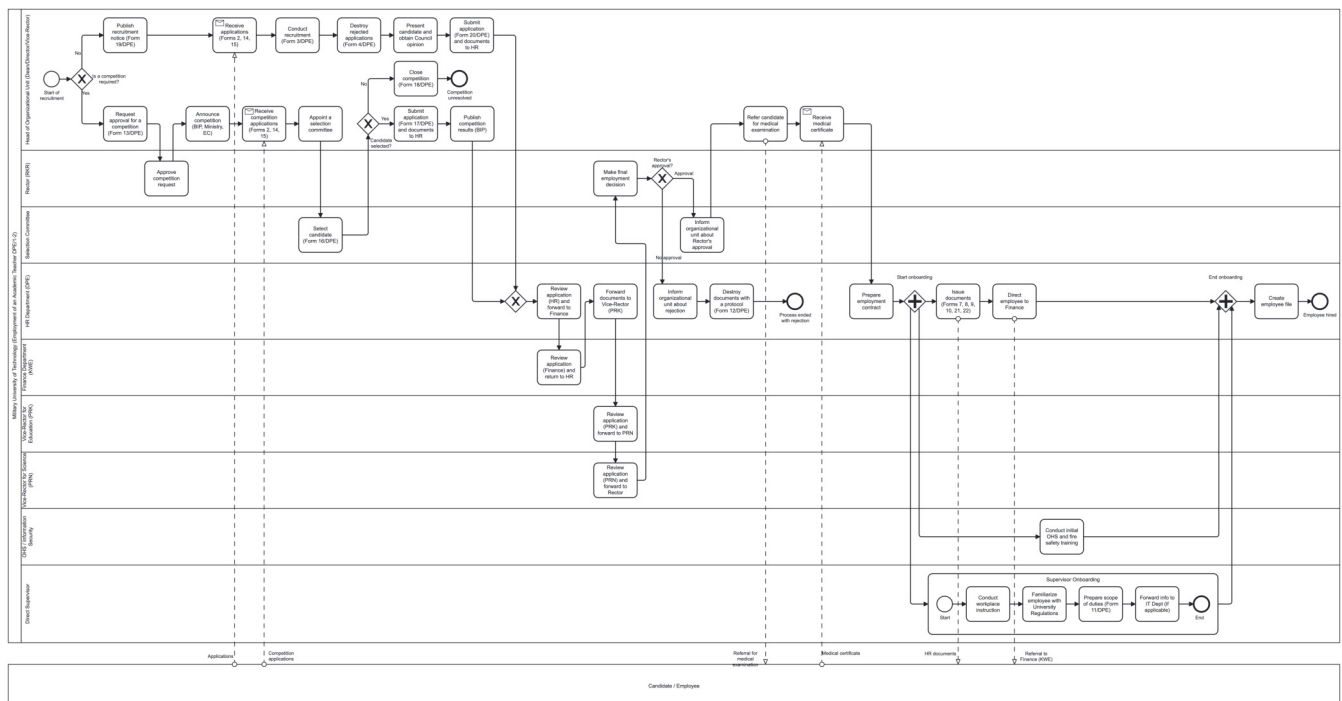


Figure 1. BPMN Model for DPE 1.2: Employment of an academic teacher.

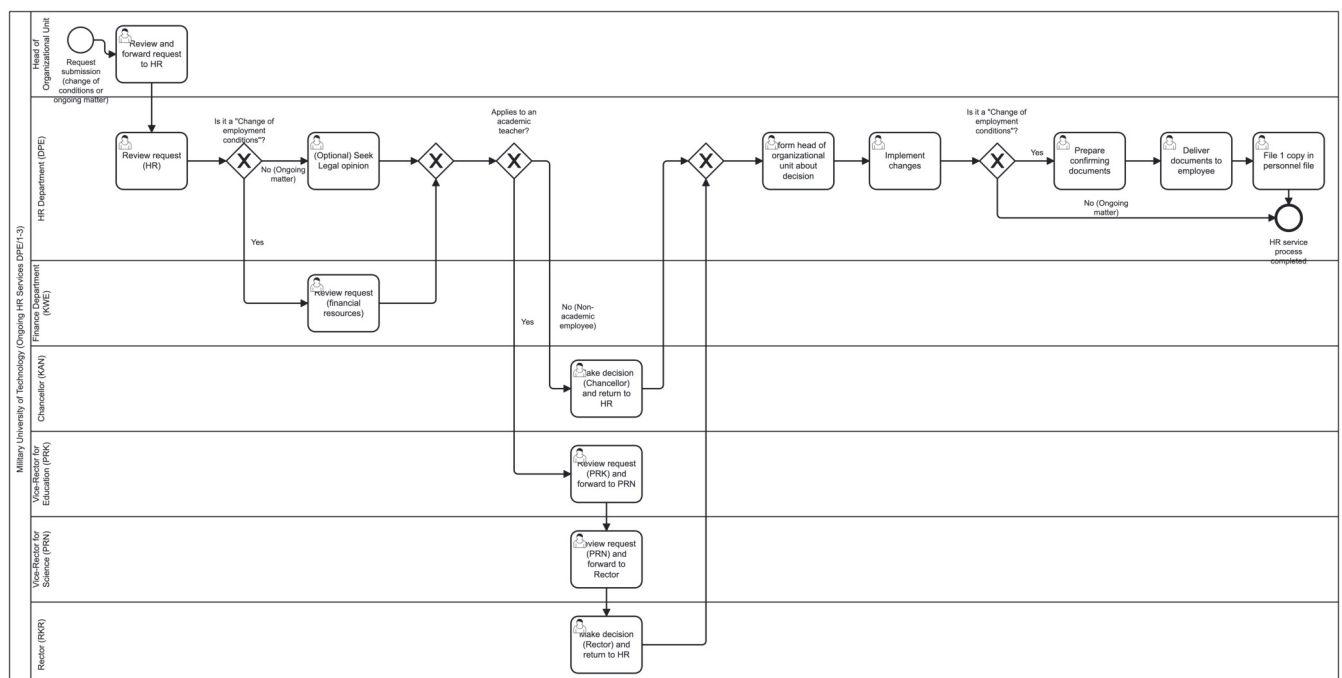


Figure 2. BPMN Model for DPE 1.3: Ongoing HR services.

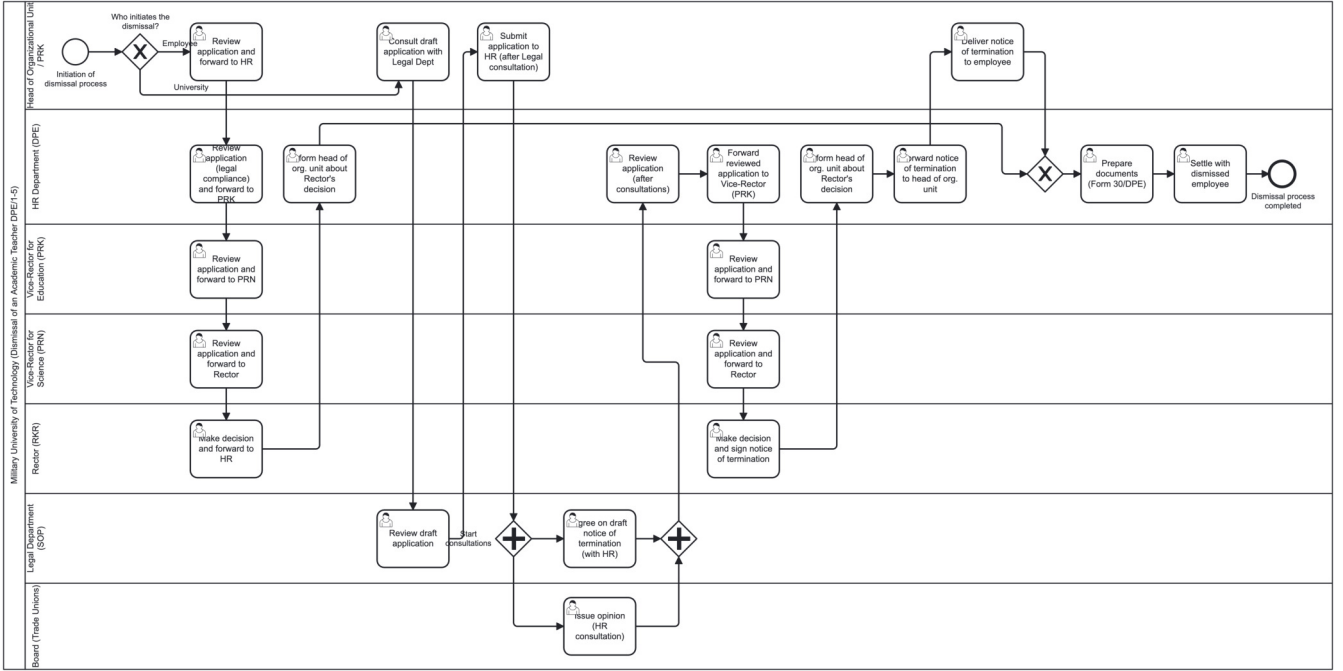


Figure 3. BPMN Model for DPE 1.5: Dismissal of an academic teacher.

relevance. The simulation parameters were derived from three complementary sources: (i) official internal procedures and normative documents that define the required sequence of actions; (ii) BPMN mapping sessions with process knowledge from the HR and administrative context; and (iii) expert estimates and historical heuristics used to parameterize task durations, branching probabilities, and arrival rates where complete event-log data were not available. The procedure documents used for mapping are internal institutional materials rather than publicly available web resources. Consequently, the model should be interpreted as a structured, scenario-based representation of the observed WAT administrative environment, not as a fully event-log-calibrated digital twin. This limitation is revisited in the conclusion, where event-log validation through SAP and EZD systems is identified as the next step.

The simulation parameters included:

- **Arrival Rates:** The frequency of incoming cases was modeled using an exponential distribution [4]. This rate varied by process and scenario. For example, in the baseline employment process (DPE 1.2), an arrival rate of one case every 40 working hours (144,000 seconds) was established. During peak load simulations (representing the start of an academic year), this frequency was dramatically increased to one case every 8 hours (28,800 seconds).
- **Task Durations:** The execution time for individual administrative actions was modeled using a normal distribution, characterized by a mean and standard deviation derived from expert interviews and historical heuristics [4]. For instance, the selection of a candidate by the Competition Committee required an average of 8 hours ($\sigma = 2$ hours).

- **Branching Probabilities:** Statistical probabilities were applied to XOR gateways based on institutional practice [20]. For example, the employment model assumed that 75% of recruitments follow a competitive track while 25% are non-competitive, and that 95% of requests receive a positive decision from the Rector. In ongoing services (DPE 1.3), 80% of matters were classified as purely routine, while 20% required financial consultation (KWE).
- **Systemic Phenomena:** For tasks independent of administrative working hours, a virtual 24/7 system resource was defined to prevent artificial bottlenecks in the simulation [17].

By establishing these stochastically sound baselines, the simulation environment was prepared to test specific hypotheses regarding resource allocation, delegation of authority, and workflow resilience under extreme organizational stress [5].

IV. RESULTS AND ANALYSIS

A. DPE 1.2: Employment of an Academic Teacher

The employment of an academic teacher is a critical process for a higher education institution, fundamentally determining its didactic and scientific potential [23]. From an operational perspective, this process is highly resource-intensive, encompassing recruitment, multi-tier committee evaluations, and complex onboarding procedures [14].

To accurately diagnose systemic limitations and test the resilience of this value stream, two primary optimization hypotheses were formulated prior to simulation:

- **Hypothesis 1 (H1):** The executive authority (the Rector) acts as the primary organizational bottleneck due to the

centralization of final approvals. Delegating this authority to a Vice-Rector would significantly shorten the cycle time.

- **Hypothesis 2 (H2):** The Personnel Department (DPE) is the primary constraint. Doubling the HR administrative staff would eliminate document queues and stabilize the process during demand spikes.

As detailed in Table I, the baseline scenario yields a highly stable average cycle time of 5.08 days. However, under Peak Load conditions—simulating the massive influx of hiring requests typical before the start of an academic year—the system's throughput degrades catastrophically, with cycle times reaching 385.31 days.

Detailed analysis of the simulation logs allowed us to decisively evaluate our hypotheses. The data revealed that the wait time at the Rector's desk was virtually zero (0.0 hours) across all variants [24]. Because the physical act of signing a decision takes only a fraction of an hour, the executive organ processes documents continually and does not create administrative jams. Consequently, Hypothesis 1 was firmly rejected.

While massive wait times do accumulate at the HR Specialist (733.09 hours) and Public Relations (698.68 hours) nodes during peak loads, the root cause originates much earlier in the structure [20]. The true operational bottleneck forms at the very beginning of the process with the Hiring Manager. Over the simulation of 500 cases, the Hiring Manager was forced to execute nearly 2,500 iterations of manual tasks [18]. For example, preparing a single "Competition Application" requires an average of 2.75 hours of administrative work. This immense volume of manual actions blocks the manager during peak loads. To cope, the manager resorts to "batching"—accumulating massive piles of applications and releasing them downstream all at once, which subsequently overwhelms and crashes the DPE and PR nodes.

Furthermore, the application of Activity-Based Costing (ABC) provided profound insights into the financial architecture of the process (Table II). The data indicates that the largest generator of personnel costs is not the central administration, but the Competition Committee itself [23]. Due to its collegiate nature and the necessity for in-depth candidate evaluation, the committee's tasks average 8.02 hours, generating an estimated cost of over 921,000 PLN per 500 proceedings.

Because the cycle time's sensitivity is tied to the initial batching rather than executive approvals, purely scaling the central administration is a costly misstep [20]. The Recovery Plan (Scenario C) manages to restore functionality and cap the cycle time at 15.38 days through brute-force resource augmentation. However, the Cost Optimization (Scenario D) appears to be the superior strategic choice within the simulated assumptions [5]. By streamlining the workflow, replacing manual form generation with automated IT templates for the Hiring Managers, and minimizing dependencies on non-essential parallel checks, Scenario D achieved an optimal 4.76 days average cycle time. This yields a highly efficient process at a reduced average cost of 6,676.76 PLN per case,

addressing the modeled root constraint without inflating the HR headcount [23].

B. DPE 1.3: Ongoing HR Services

This process handles routine, daily operational employee requests, status updates, and contractual adjustments. Unlike the complex recruitment workflow, ongoing services are characterized by high frequency and a majority of cases that are routine in nature [18].

To evaluate the efficiency of mass processing, two hypotheses were tested:

- **Hypothesis 1 (H1):** The Personnel Department (DPE) constitutes a critical operational bottleneck because it must handle every request at multiple stages of the procedure.
- **Hypothesis 2 (H2):** The University Board (Rectorate, Chancellor) does not significantly impact the cycle time for routine matters, as their role is marginal regarding the volume of routine cases.

The simulation results revealed a phenomenon defined as a "scale bottleneck." In the baseline scenario (Scenario A), the process is efficient, with an average cycle time of 0.75 days. However, when demand doubles during peak load (Scenario B)—simulating periods such as the start of an academic year or massive legislative changes—the system suffers a catastrophic collapse, with cycle times rising to 15.27 days.

Data analysis confirmed that adding executive capacity (Scenario C) yielded virtually no improvement, confirming H2 [23]. Conversely, the DPE was identified as a "hard" operational bottleneck. For a sample of 500 cases, DPE specialists performed a total of 2,950 tasks—accounting for over half of all actions in the system [18].

The application of Activity-Based Costing (ABC) highlighted deep systemic waste [17]. High-level tasks, such as manually entering changes into the IT system and preparing simple routine documents, cost the university approximately 26,000 PLN per 500 cases. This indicates a significant loss of highly qualified HR labor on repetitive "data entry" [13].

The Cost Optimization scenario demonstrated that streamlining these routine workflows—specifically by bypassing unnecessary legal reviews (SOP) for basic requests—maintains sub-day cycle times even under high load [5]. The results therefore support treating Employee Self-Service and workflow simplification as candidates for pilot testing rather than as immediate universal solutions. In particular, routine data entry and document-generation steps appear to be the most plausible automation targets [7], [8].

C. DPE 1.5: Dismissal of an Academic Teacher

The dismissal process requires strict legal compliance, union consultations, and multi-tier executive sign-offs [23]. This procedure is characterized by a higher degree of formalization compared to hiring, primarily due to the necessity of engaging additional stakeholders such as the Legal Support Section (SOP) and the Trade Union Board [15]. To evaluate the efficiency and constraints of this workflow, two primary hypotheses were formulated:

Table I
SIMULATION KPIs FOR DPE 1.2: EMPLOYMENT PROCESS

Scenario	Avg Cycle Time (Days)	Avg Cost (PLN)
A_Baseline	5.08	7169.38
B_Peak_Load	385.31	8198.57
C_Recovery_Plan	15.38	4800.07
D_Cost_Optimization	4.76	6676.76

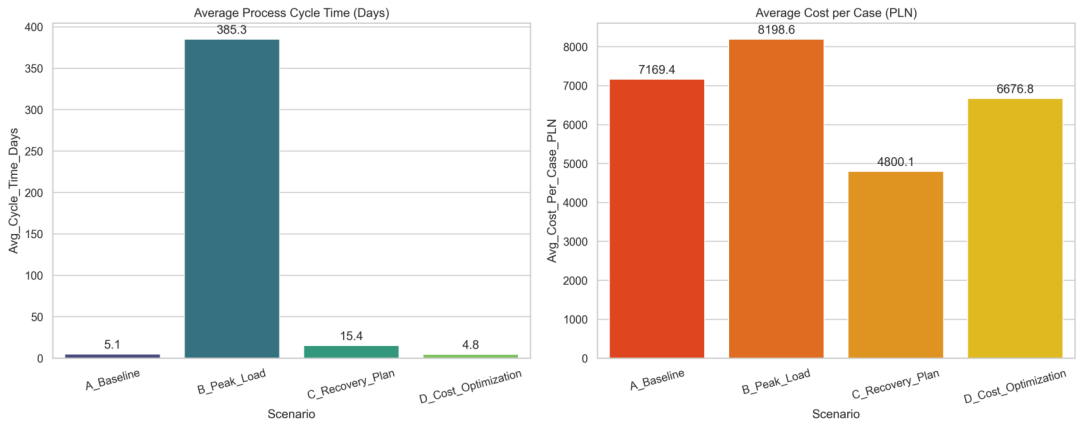


Figure 4. Scenario Comparison Chart for DPE 1.2.

Table II
AGGREGATED RESOURCE UTILIZATION AND COST (TOP 5) FOR 500 CASES

Organizational Resource	Task Count	Total Hours	Total Cost (PLN)
Competition Committee	383	3070.76	921,228.31
Hiring Manager	2492	2733.91	382,746.85
Direct Supervisor	1520	1708.84	187,971.95
Personnel Dept (DPE)	2260	2785.72	167,143.29
Vice-Rectors (PRK, PRN)	760	748.63	134,752.57

Table III
SIMULATION KPIs FOR DPE 1.3: ONGOING SERVICES

Scenario	Avg Cycle Time (Days)	Avg Cost (PLN)
A_Baseline	0.75	764.96
B_Peak_Load	15.27	1316.46
C_Recovery_Plan	0.89	1023.98
D_Cost_Optimization	0.79	998.03

Table IV
KEY TASK STATISTICS FOR ONGOING SERVICES (500 CASES)

Task Name	Executions	Avg Time (h)	Total Cost (PLN)
Review and Forward (Unit)	500	0.51	35,946.04
Prepare Confirmation Documents	500	0.52	15,610.15
Optional Legal Consultation (SOP)	400	0.49	11,785.60
Review Application (DPE)	500	0.34	10,260.67
Enter Changes	500	0.34	10,178.68

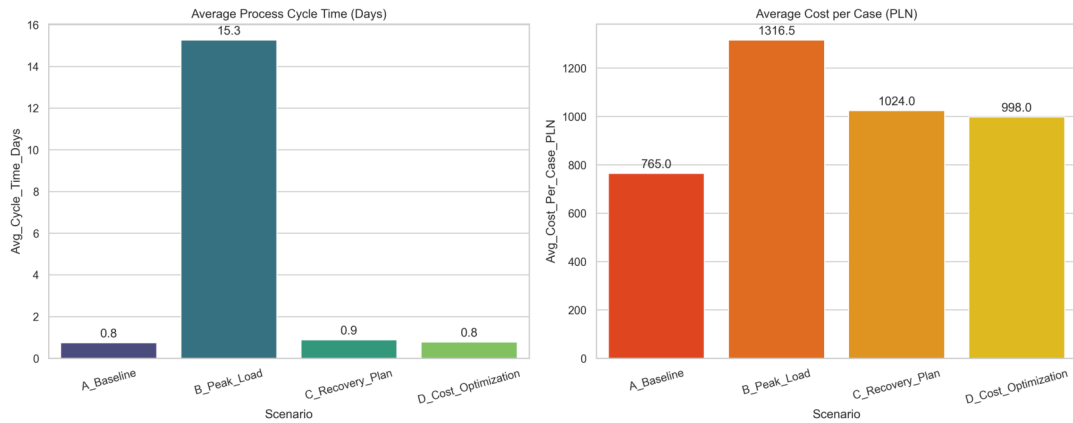


Figure 5. Scenario Comparison Chart for DPE 1.3.

- **Hypothesis 1 (H1):** The primary organizational bottlenecks are the extended legal consultations (SOP) and the document circulation within the Trade Union Board.
- **Hypothesis 2 (H2):** The Personnel Department (DPE), burdened with the preparation of settlement documentation and clearance slips (clearance slips”), blocks the efficient finalization of the process under increased workloads.

Simulation analysis reveals that while baseline performance is rapid at 0.82 days, the Peak Load scenario—representing a fivefold increase in application volume—drives the cycle time up to 86.01 days. Data presented in Table V decisively confirms H2 while overturning the assumption that executive authorities (the Rectorate) represent an operational bottleneck [20]. Even with increased workloads, the Rector’s decision time remains short; increasing Rectorate resources (Scenario C) failed to improve cycle times, whereas doubling DPE resources (Scenario D) neutralized the blockage and restored the cycle time to 15.03 days.

The implementation of Activity-Based Costing (ABC) revealed a phenomenon described as a “cost bottleneck.” While the SOP does not block the process flow in terms of volume—executing only 293 tasks compared to nearly 3,000 by DPE—it consumes a disproportionately large portion of the budget [17]. The task “Zaopiniuj projekt wniosku” by SOP takes an average of 4.03 hours, making it the most expensive individual activity in the entire process at a total cost of approximately 177,000 PLN per 500 cases. This stems from a lack of standardized legal templates, requiring individual analysis for each instance [20].

The Cost Optimization strategy mitigated these bottlenecks by consolidating tasks and leveraging standardized digital templates [7], [8]. Under this scenario, the DPE resource carried out 3,035 executions, and despite this high utilization, the overall process cycle time fell to 0.80 days. Results suggest that the optimization of dismissal procedures must be twofold: operational relief for the DPE through the full digitalization of clearance slips and cost-reduction for the SOP through the implementation of pre-approved legal templates [13], [12].

V. STRATEGIC RECOMMENDATIONS

Based on the synthesis of the “as-is” models and the results of the stochastic discrete-event simulations, several systemic dysfunctions within the HR architecture of the Military University of Technology (WAT) have been identified. These range from operational bottlenecks to cost asymmetries [20]. To move the organization toward a “to-be” state, the following three evidence-informed improvement directions are proposed for pilot testing and further validation:

A. Digital Transformation and Employee Self-Service (ESS)

The simulation of the DPE 1.3 (Ongoing Services) process demonstrated a significant “scale bottleneck,” where the volume of routine tasks overwhelms the Personnel Department [23]. To mitigate this without increasing permanent headcount, the university could consider the following interventions:

- **Pilot an Employee Self-Service (ESS) Platform:** Shift the responsibility for initiating and entering data for routine requests directly to the employees [7], [8].
- **Assess Data Entry Automation via ERP Integration:** Utilize the university’s SAP or ERP systems to automatically map data from e-forms to employee profiles upon manager approval, eliminating manual re-keying [22], [2].
- **Evaluate Robotic Process Automation (RPA):** Use software robots to handle the aggregation of data and the generation of standardized PDF documents [13], [7].

B. Standardization and Legal Compliance Optimization

The analysis of process DPE 1.5 (Dismissals) revealed a “cost bottleneck” where legal reviews (SOP), though low in volume, accounted for the highest individual task costs due to a lack of standardization [20].

- **Develop a Pre-Approved Template Catalog:** Create a comprehensive set of legally vetted templates for contracts and dismissal notices [8].
- **Pilot Digital Clearance Slips (“Obiegówka”):** Fully digitizing this workflow within the Electronic Document

Table V
SIMULATION KPIS FOR DPE 1.5: DISMISSAL PROCESS

Scenario	Avg Cycle Time (Days)	Avg Cost (PLN)
A_Baseline	0.82	1024.40
B_Peak_Load	86.01	1465.22
C_Recovery_Plan	0.95	1094.92
D_Cost_Optimization	0.80	966.85

Table VI
KEY TASK STATISTICS FOR DISMISSAL PROCESS (500 CASES)

Task Name	Executions	Avg Time (h)	Total Cost (PLN)
Settle Employee Clearance	500	4.27	96,174.62
Review Draft (SOP)	293	4.03	177,002.50
Review Application (DPE)	500	3.24	72,837.13
Consult Draft (Unit)	293	1.96	80,562.33
Issue Opinion (Trade Union)	147	3.91	57,467.42

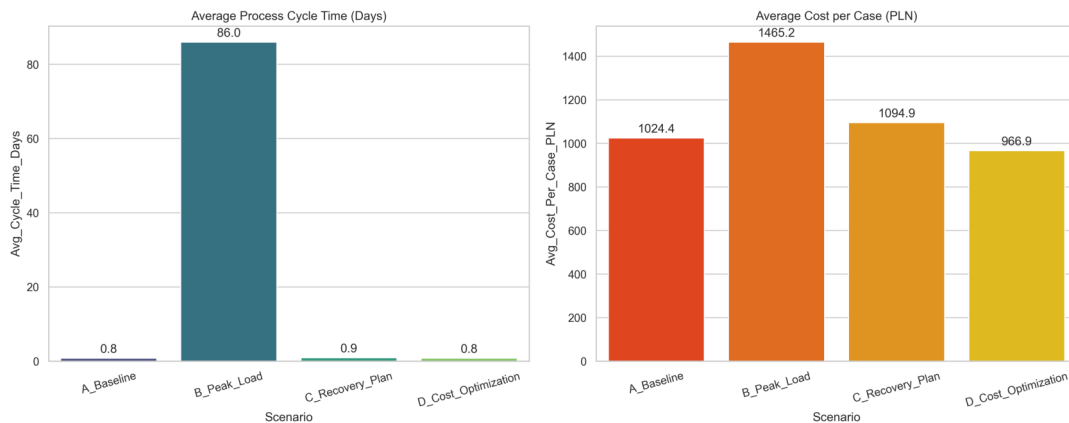


Figure 6. Scenario Comparison Chart for DPE 1.5.

Management (EZD) system would remove a primary operational constraint [15].

C. Decentralization and Decisional Parallelization

The DPE 1.2 (Employment) simulation showed that while the Rector's office is not a bottleneck in terms of individual task time, the centralization of all signatures creates a sequential dependency that is vulnerable to peak loads [23], [20].

- **Assess Delegation of Decision-Making Authority:** Review and update internal normative acts to allow the delegation of signature authority for routine staffing matters to Vice-Rectors or Faculty Deans [24].
- **Selective Resource Parallelization:** Increasing the pool of available decision-makers (parallelization) is highly effective at reducing overall Lead Time during peak volume [16].

Expected Benefits and Research Outlook

If validated in pilots, these interventions may help the administration move from a predominantly paper-based and role-sequential model toward a more standardized and digitally

supported academic administration [7], [9]. The simulations suggest that reducing the “scale bottleneck” through better standardization, ESS, and selected automation can generate measurable time and cost benefits [23].

Future research should transition from stochastic simulations to **Process Mining** [27]. By utilizing actual event logs from the university's SAP and EZD systems, the institution can move toward an algorithmic, real-time audit of process efficiency, ensuring continuous optimization [16].

VI. CONCLUSION

This study validates the application of stochastic discrete-event simulation as a robust tool for analyzing and optimizing complex administrative workflows within Higher Education Institutions [16]. By modeling the real-world organizational environment of the Military University of Technology, we have moved beyond static BPMN mapping to a dynamic, quantitative evaluation of process resilience [19], [23], [27].

The simulation experiments across three critical HR domains—Employment (DPE 1.2), Ongoing Services (DPE 1.3), and Dismissals (DPE 1.5)—revealed that baseline configura-

tions in a highly formalized university setting are extremely vulnerable to demand surges [20]. Key systemic findings include:

- **Decoupling Decisional and Operational Bottlenecks:** Contrary to initial hypotheses, the executive authority (the Rector) does not constitute an operational bottleneck, as task execution times at the highest levels are minimal [23]. Instead, delays are primarily driven by manual document preparation at the start of the value stream and "scale bottlenecks" in routine processing [18], [24].
- **The Cost of Non-Standardization:** The analysis of dismissal processes highlighted a significant cost asymmetry [17]. While legal reviews are low in volume, they represent a "cost bottleneck" due to the lack of standardized templates, consuming a disproportionate share of the operational budget [20].
- **Data Entry Waste:** In routine services, it was empirically demonstrated that high-qualified HR specialists spend the majority of their time on manual "data entry" [13]. This repetitive work accounts for a deep waste of organizational resources that could be mitigated through automation rather than staff expansion [25], [23].

The strategic recommendations formulated—comprising pilot testing of Employee Self-Service (ESS) platforms, selective Robotic Process Automation (RPA) for standardized document generation, and a review of signing authority rules—should therefore be understood as evidence-informed redesign options rather than fully validated implementation prescriptions [7], [8], [24]. In the simulated scenarios, these interventions restored acceptable cycle times and reduced selected cost components, but their organizational feasibility requires empirical validation before full-scale deployment [23].

The study has several limitations. First, the stochastic parameters were derived from internal procedures, expert consultation, and historical heuristics rather than from a complete event-log extraction. Second, the case study concerns a specific military-civilian university, and the results should therefore be generalized cautiously to other HEIs. Third, although the scenarios vary workloads and resource configurations, a broader sensitivity analysis of arrival rates, task durations, and resource calendars remains necessary. Future research will focus on the transition from stochastic simulations to *Process Mining* [27], [10]. By utilizing actual event logs from the university's EZD and SAP systems, it will be possible to calibrate probability distributions, validate modeled bottlenecks against observed behavior, and support continuous, evidence-based monitoring of procedural efficiency [3], [2].

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