POLITECNICO MILANO 1863

SCUOLA DI INGEGNERIA INDUSTRIALE E DELL'INFORMAZIONE

LAUREA MAGISTRALE IN MECHANICAL ENGINEERING

EXECUTIVE SUMMARY OF THE THESIS

Pre-Production of an educational serious game on coordinated Business Continuity Management

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1. Introduction

Business continuity management (BCM) is a rising concern for firms all over the world. BCM is a process that actively ensures operational continuity in order to maintain a competitive advantage. Applying an effective BCM plan may help with both reputation protection and the recovery process; also, building an effective BCM can help a business get a better understanding of important operations. Recently, the awareness of the importance of using game-based simulations in the field of Business Continuity Management has increased. Game-based simulations can be used to educate learners on best practices in business continuity management in a quick, efficient, and cost-effective manner. The reason is that these games place learners in scenarios that are close to real life, and the learners enter an environment where it is safe to make mistakes, which aids the learning process. In addition, Game-based simulations can be used to ensure that a Business Continuity Management is implemented successfully by assessing if the business continuity plans will perform as intended in real scenarios since these games are the closest to actual execution. Furthermore, Game-based simulations can be used to test and regularly update business continuity plans, to assure that they are effective and to guarantee that corporate activities do not come to a standstill in the event of unforeseen events.

The objective of this study is to make a pre-production of an educational serious game on collaborative business continuity management. It consists of the development of the main concepts and ideas, creating a storyline and the game flow, designing player tasks and building a Simulink model to simulate players business continuity plans performance. The game is built around a fictional manufacturing company and the simulation model takes into account company's internal and external interdependencies and a series of player decisions related to company's business continuity plan. The activities covered in this work are the first step in the development of the serious game focused on collaborative Business Continuity Planning. The aim of the educational serious game is to educate students in Business Continuity Management best practices in a fast, effective and cost-efficient manner. Furthermore, to prove the importance of coordinated Business Continuity Management to deal with large-scale disasters like earthquakes.

2. Study Methodology

The study starts with building a fictional case study of three interdependent organizations located in the same area. The fictional case study is loosely based on real events, organizations and people, in order to have a realistic game, but do not utilize real people's or organization's names. The story investigates the case study of three organizations which are hit by an earthquake in an earthquake-prone area. These three organizations are a manufacturing company, which is central in the game, and two organizations providing services: an electricity provider and a logistics provider, which is a seaport. These organizations are interdependent as they exchange services along the same value chain, and share similar risks since they are in the same geographical area. During building the case, the first draft of all the needed information is provided, as educated estimates, and will be further calibrated during the simulation model testing and validation.

After building and completing the fictional case and covering all the information necessary for working on companies' business continuity plans, a Simulink model is developed to model external interdependencies between the three companies, in addition to internal interdependencies between business functions within the manufacturing company. The model is also used to model the application of business continuity strategies within the manufacturing company to investigate their impact on the performance of all business functions of the company over time. This model will be the back engine of the educational serious game.

3. General game flow

Figure 1 shows the general flow of the game. In this game, a student or group of students will act as the business continuity team of the manufacturing company. They will be provided with a description of the company and its financial data. After that, the team will be required to estimate the financial impact of the corresponding company, determine which are the critical assets and functions in the company, and define the recovery objectives for each business function in the company. Then an earthquake threat description and vulnerability estimate for the company will be provided. The next stage of the game is the risk evaluation for each business function in the manufacturing company. In this stage, the team will receive automated inputs about recovery parameters from the other two external organizations which are electricity and logistics providers. These inputs must be considered when deciding on the manufacturing company coordinated BCP due to interdependencies between the three organizations. Then, the BCM team in the manufacturing company has to manage the risk of every business function by either accepting, reducing or transferring the risk for each business function within the company. For reducing the risk, suggested recovery strategies will be provided to the BCM team to choose from. The next step is to perform an earthquake scenario simulation in the area and investigate the performance of the manufacturing company just after an earthquake. Finally, the game will show the results of the scenario simulation for the organization. The result include the financial loss and business functions performances of the manufacturing company.

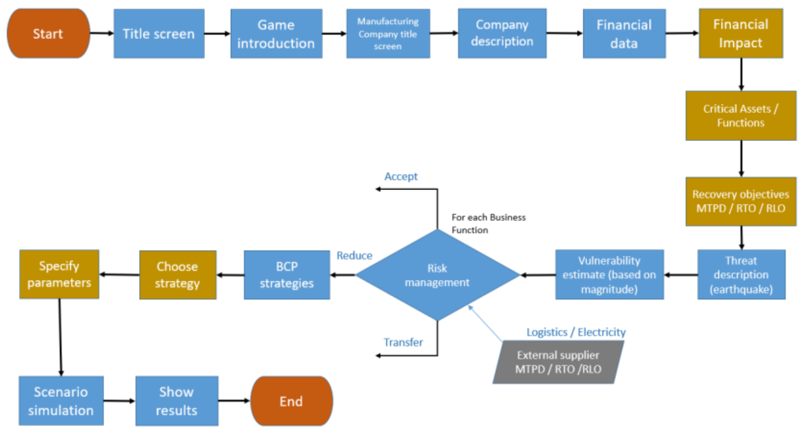


Figure 1 General Game Flow

4. The case study

The following fictive case study serves as a case to base the educational serious game on collaborative business continuity planning, and it describes three interdependent organizations which are located in central Italy. These organizations are an auto-parts manufacturing company, an electricity provider and a port. Sources [1], [2], [3], [4] and [5] have been utilized to help in building this case study.

4.1. Manufacturing Company

Carware is an auto-parts manufacturing company which has 120 employees who work out of a single location in a light industrial area in central Italy. They manufacture and sell casted and machined aluminum auto-parts. The customers call in orders regularly. They also run a website that has seen sales grow significantly, so that Web sales are now equal to a quarter of total sales. Carware makes about €300 million a year in sales, about a quarter of that online. As shown in Figure 6, Carware consists of three main facilities. The main one is a large space comprised mostly of manufacturing space and some office space. In addition, another facility is the Warehouses in which there are four physical stocks which are Raw Material stock, Finished Products stock, Internal Parts stock and External Parts stock. The third facility is the Logistics Center, which is responsible for assembly, loading and unloading processes. They ship and receive packages daily for Web operations and they ship weekly for their non-Web customer orders.
Figure 2 shows the physical and informational flows between all business functions within Carware, and also shows the flows coming from external providers that Carware relies on to function. Blue blocks represent the business functions of Carware, green blocks represent logical and physical stocks of Carware, and brown blocks represent the external services needed by Carware in order to operate and these services are provided by external providers.

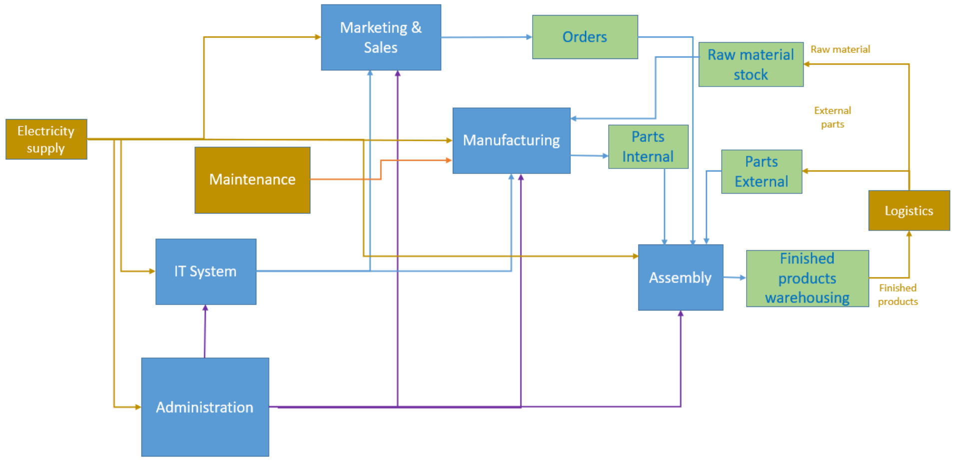


Figure 2 Physical flow and Information flow Diagram of Carware

4.2. Electricity Provider

Electricity Authority (EA) is a state-owned utility in central Italy. The organization responsibility is to distribute electric power to the customers in central Italy covering 3,192 sq.km. Electricity Authority receives power from the Electricity Generating Authority (EGA) of Italy at high voltages and then EA reduces them to low voltages at distribution substations and then distributed to customers. EA makes about € 400 million a year in sales of electric energy.
Electricity Authority defined its recovery parameters in case of earthquakes to be automated inputs to manufacturing company. These parameters are Maximum Tolerable Period of Disruption (MTPD), Recovery Time objectives (RTO), and Recovery Level Objectives (RLO). The Maximum Tolerable Period of Disruption (MTPD) of the Electricity Authority is defined as 45 days. In addition, the Recovery Level Objective (RLO) of the Electricity Authority is defined as 50% of the normal performance. The Recovery Time Objective (RTO) of the Electricity Authority is defined as 25 days.

4.3. Logistics Provider

The seaport that is owned and administered by the Italian government has two terminals: Terminal 1 which has two berths namely, berth 1 and berth 2, both are utilized for commercial ships, besides one area for fishing boat service; and Terminal 2 which also has two berths namely, berth 3 and berth 4, both are utilized for commercial ships. The port's core functions include the operations of a multi-purpose terminal at berths 1 and 2, and the operations of a container terminal at berths 3 and 4. The port provides a "logistic center" service which is a complementary business to the business of the seaport. The logistic center also assists manufacturing industries by delivering imported materials to local businesses and transferring exported unit loads to the port terminal.

The port defined its recovery parameters in case of earthquakes to be automated inputs to the manufacturing company. These parameters are Maximum Tolerable Period of Disruption (MTPD), Recovery Time objectives (RTO), and Recovery Level Objectives (RLO). The Maximum Tolerable Period of Disruption (MTPD) of the port is defined as 90 days. In addition, the Recovery Level Objective (RLO) of the port is defined as 60% of the normal performance. The Recovery Time Objective (RTO) of the port is defined as 45 days.

5. The Simulation Model

This research utilizes a widely known scientific and engineering modelling tool which is MatLab Simulink. Figure 3 shows the overall system model of the manufacturing company, which includes the main business functions of the company, the stocks of the company, the electricity input, which is supplied by an external provider, maintenance input which is provided by an external service provider, and logistics service which is provided by an external logistics provider.

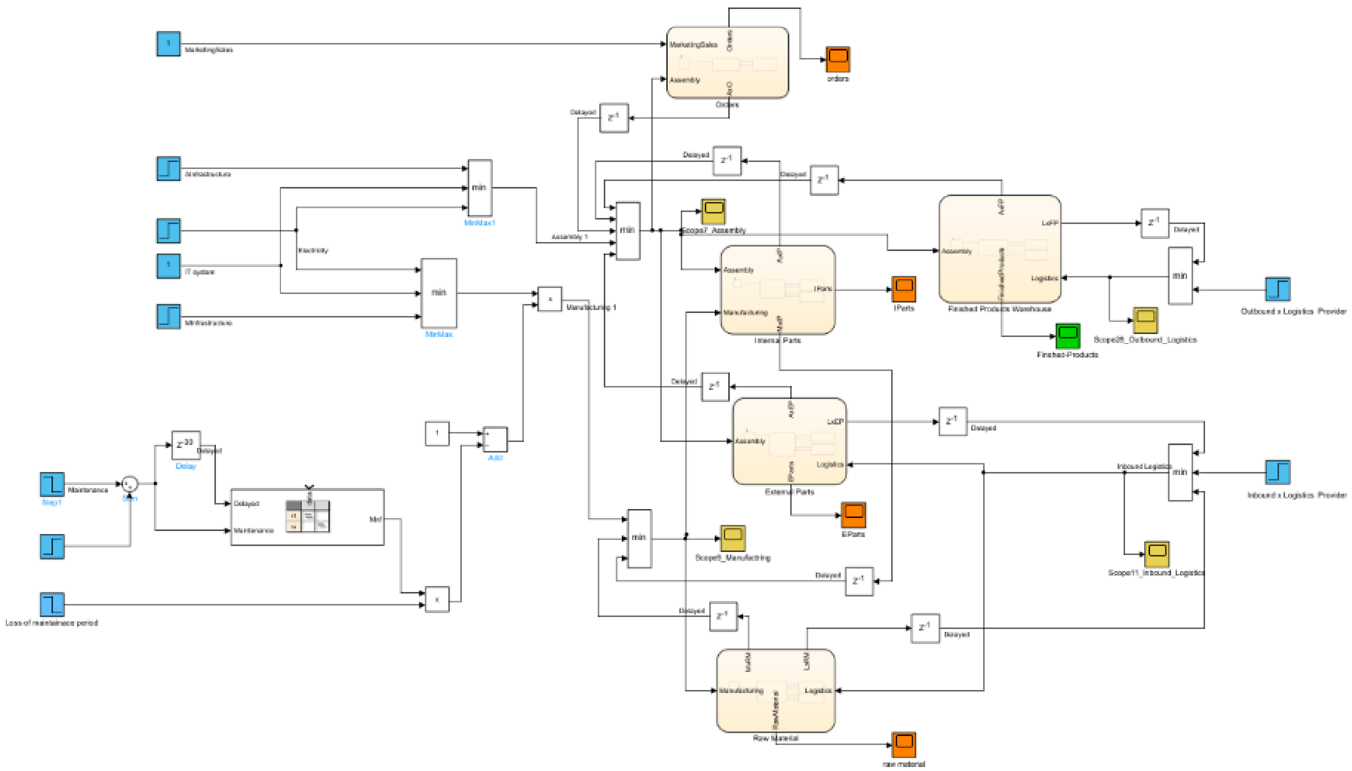


Figure 3 The overall system model of the manufacturing company

The following equations are used to calculate the performance of each business function with time:

- **Performance of Manufacturing = MIN (Manufacturing 1, MxRM, MxIP)**

<u>Where:</u>
Manufacturing 1 = MIN (Manufacturing Infrastructure, Electricity, IT system) * (1-Mnt**'**)
Mnt**'** is the inoperability due to missing maintenance
MxRM: Limit to Manufacturing performance coming from Raw Material storage when the stock is gone
MxIP: Limit to Manufacturing performance coming from Internal Parts stock when the stock is gone.

- **Performance of Assembly = MIN (Assembly Infrastructure, Electricity, IT system, AxEP, AxO, AxIP, AxFP)**

<u>Where:</u>
AxEP: Limit to Assembly performance coming from External Parts stock when the stock is gone.
AxIP: Limit to Assembly performance coming from Internal Parts stock when the stock is gone.
AxO: Limit to Assembly performance coming from Orders when the stock is gone.
AxFP: Limit to Assembly performance coming from Finished Products storage when the stock is gone.

- **Performance of Outbound logistics = MIN (Outbound x Logistics Provider, LxFP).**

<u>Where:</u>
LxFP: Limit to performance of Outbound Logistics coming from the performance of Finished Products stock when the stock is gone.
Outbound x Logistics Provider: The performance of Outbound logistics coming from the performance of the external logistics provider.

- **Performance of Inbound logistics = MIN (Inbound x Logistics Provider, LxEP, LxRM).**

<u>Where:</u>
LxEP: Limit to performance of Inbound Logistics coming from the performance of External Parts stock when the stock is gone.
LxRM: Limit to performance of Inbound Logistics coming from the performance of Raw Material Stock when the stock is gone.
Inbound x Logistics Provider: The performance of Inbound logistics coming from the performance of the external logistics provider.

In the model, there are 4 physical stocks and one logical stock. These stocks are modelled using State Chart where four different states are defined:

- **Initiation** – where the initial values are defined, such as the initial level of stock and the default values of parameters representing limitations due to inoperability (1, as there is no inoperability in normal operation).
- **Update** – used for the period of normal operation where at each step the level of stock is updated by adding inputs to the stock and subtracting the outputs consumed from the stock.
- **Full** – this is one extreme state, when the level of the stock reaches its maximum value, i.e. it is full. This situation is not a limiting factor for a business function that consumes from the stock, but it is for business function that tops up the stock. In this case, the inoperability propagates backwards.
- **Empty** – this is the other extreme state, when the stock is fully consumed and drops to zero. This situation is not a limiting factor for a business function that tops up to the stock, but it is for a business function that consumes the stock. In this case, the inoperability propagates forward.

The equations used in the update state for each stock in the model are:

  - Raw Material = Raw Material + Logistics – Manufacturing.
  - Internal Parts = Internal Parts + Manufacturing – Assembly
  - External Parts = External Parts + Logistics – Assembly
  - Finished Products = Finished Products + Assembly – Logistics
  - Orders = Orders + Marketing and Sales – Assembly

6. BCP performance evaluation

The players will be the business continuity team of the manufacturing company and they will face a series of choices to decide on the key BCP strategies and their parameters. These choices impact the performance in an earthquake scenario, and players are scored based on these outcomes. In order to evaluate the performance of the BCP, total financial losses and costs have to be calculated to see whether chosen BCP is economically feasible or not. The financial performance is calculated as the sum of: losses from business disruption or its lower-level performance, BCP setup costs, and BCP deployment costs.

Losses from business disruption of lower-level performance includes all financial losses due to disruptions of business functions. It includes loss of sales, contractual penalties, loss of the competitiveness and market share of Carware, and loss in the reputation of Carware.

BCP setup costs are the money invested in advance in order to have business continuity options and to be ready for any disruptive event. For example, the cost of increasing the warehouse capacity, the cost of factory's partial transfer strategy, and the cost of backup equipment strategy are all considered as BCP setup costs. Whereas BCP deployment costs the money invested to have reactive practices in order to have business continuity options and to mitigate the consequences of any disruptive event. For example, the cost of alternative shipping strategy and the cost of alternative maintenance provider are considered as BCP deployment costs.

Financial losses we be calculated on a daily basis from the simulation model. After calculating the total financial losses and total BCP setup and deployment costs, the performance of the BCP in an earthquake scenario can be evaluated.

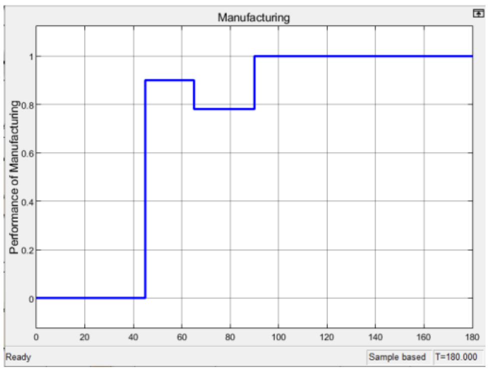
7. Model testing

A severe earthquake, with strength equal to 8 on the modified Mercalli scale, was assumed to hit the area of the three organizations. The assumed consequences of that earthquake are as follows:

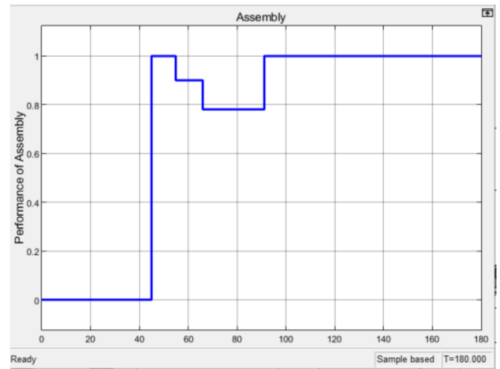
The performance of the electricity provider will be disrupted for 30 days and then it will be fully recovered. In addition, the performance of the seaport logistics provider will be disrupted for 45 days and then it will be fully recovered. Moreover, the manufacturing infrastructure, which includes manufacturing equipment and building, will be fully disrupted for 45 days, and then its performance will be fully recovered. Similarly, the Assembly infrastructure, which includes assembly equipment and building, will be fully disrupted for 45 days, and then its performance will be fully recovered. Since 80% of the parts stocks and finished products would be lost due to the earthquake, the initial level of

Internal Parts will be one day of manufacturing at fully capacity. Similarly, the initial level of External Parts will be two days of assembly at fully capacity. The initial level of Finished Products will be one day of assembly at fully capacity. Furthermore, the initial level of Raw Material will be two days of manufacturing at fully capacity. In addition, the loss of maintenance period is 90 days. However, IT system, administration, and Marketing and Sales could work remotely, so their performances will not drop.

By inserting these values of this scenario as inputs to the simulation model, the output performances of the main business functions of Carware are shown in Figure 3.



(a)



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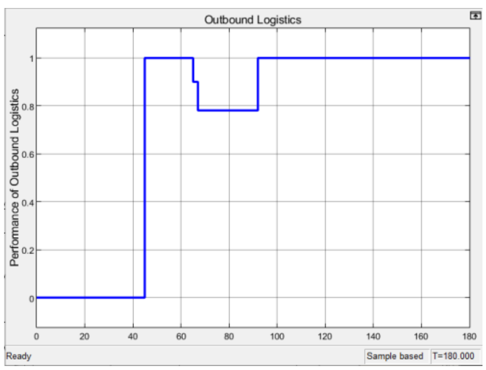
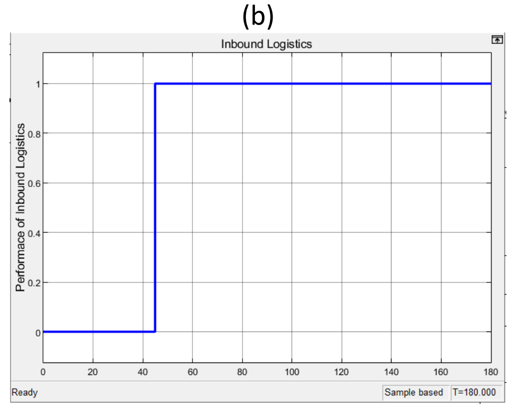


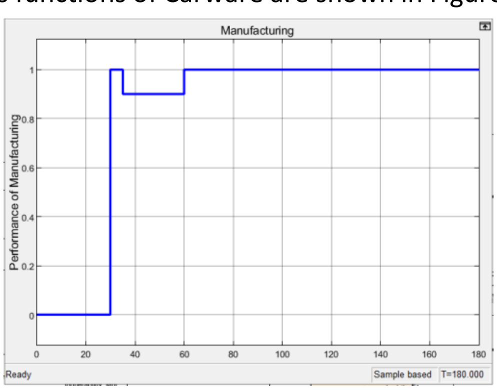
(c)



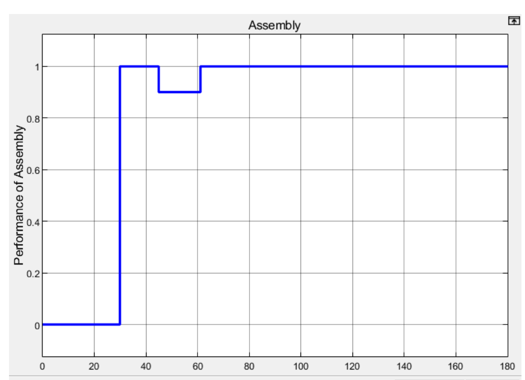
(d)

Figure 4 Performances of (a) Manufacturing, (b) Assembly, (c) Outbound logistics and (d) Inbound logistics after the chosen earthquake scenario

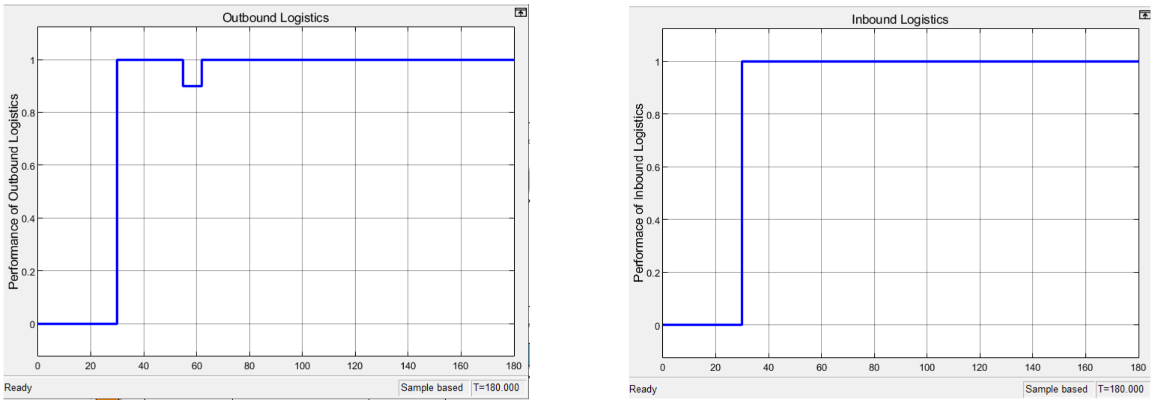
A combination of recovery strategies was chosen from suggested ones based on the outcomes of the scenario. These selected recovery strategies are going to be applied to the chosen earthquake scenario to investigate the performances of all business functions of Carware after applying the strategies. The selected recovery strategies that have been applied in the chosen earthquake scenario are alternative shipping, backup equipment, and an alternative emergency maintenance provider. By applying these strategies in the simulation model, the output performances of the main business functions of Carware are shown in Figure 4.



(a)



(b)



(c) (d)

Figure 5 Performances of (a) Manufacturing, (b) Assembly, (c) Outbound logistics and (d) Inbound logistics after applying the recovery strategies to the earthquake scenario

It is clear that applying this combination of the three recovery strategies improved the performance of the business functions of Carware for chosen earthquake scenario. Furthermore, the presented simulation model is ready to be used for different earthquake scenarios and with different recovery strategies.

8. Conclusion and Recommendations

The simulation model presented by this study is ready to be used for different earthquake scenarios and different recovery strategies. The simulation model enables players to choose appropriate combinations of recovery strategies for different earthquake scenarios to be prepared for any earthquake scenario. Using this simulation model to prepare for earthquakes will save time and money compared to traditional methods, and it will provide more accurate results. Furthermore, this model is flexible in sense that any other recovery strategy, other than the suggested ones, can be simulated and applied in the model. As a result, this simulation model is ready to be used as a back engine for the Area BCM educational serious game.

The model has a couple of limitations due to the simplified concepts that were assumed during developing the Simulink model. One of these simplified assumptions is the impact of the lack of Maintenance on the performance of Manufacturing, approximated as a step function. Also, the instant recovery of the business function that is assumed upon the restore of the necessary inputs. In real cases, the recovery process could take days and it happens gradually. Another approximation in the simulation model is using the simulation step of a day, so what happens within the day is not considered and the performances and stock levels are measured on daily level. Another limitation is that the consumption rate of each stock is assumed to be equal to the top up rate of the stock. Furthermore, we do not distinguish between different types of parts used in Assembly process, only between two categories – internal and external parts. Finally, for the simplicity, we assumed a constant use of both types of parts (internal and external) in Assembly. However, all of these approximations will not disturb the comparison of the company's performance under different BC plans, and the quality of players' decisions.

In future development, the stories around the electricity provider and the logistics provider might be further developed into full game choices. Therefore, instead of having one team of players act as BC team of one company and get automated inputs from the other two companies, there will be three teams and each team will act like a BC team of one company. During the game, they have to exchange recovery objectives to develop their BCPs accordingly.

In future studies, the Cosmetecor technology capabilities can be integrated to improve the coordinated BCM between the three organizations for the earthquake scenario. The Cosmetecor technology will provide companies with an early warning a few days before the occurrence of an earthquake. The technology may provide information about upcoming earthquakes like the timing, location and severity of the earthquake. As a result, players will have an opportunity to adjust their coordinated business continuity plans accordingly and be prepared for the earthquake. Then, players could evaluate how this technology can improve the entire risk management and business continuity management.

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