Development of Multi-Objective Models in Zone-Based Dynamic Layout : Literature Review

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Abstract. One of the most challenging aspects of the industrial environment in the 21st century is the uncertainty of production. Changes that occur affect the dynamic layout of facilities that are influenced by mix products and market demand. From identification of review and analysis journals that are carried out based on grouping in terms of the methods used and grouping of parameters, also for the formulation of advanced research based on the development of future methods and complexity considerations, the emphasis on the development of facility layout leads to dynamic changes in facility layout based zones with a multi-objective approach taking into account the dynamicism of the area, production, production routes, location, cost, multi-stage and the challenge of changes to the complexity of the layout that has not been done by previous researchers. Also made a milestone in the research journey about dynamic facility layout starting from 1986 to 2017. The research methodology was conducted through four stages consisting of system analysis (entity system analysis), uncertainty analysis (forecasting method), dynamic facility multi-objective layout, and strategies and change (simulation) scenarios. The research was carried out on companies that were volatile, such as factories, furniture, electronics, and others.

Keywords : Dynamic Facility Layout, Multi-Objective, Zone-Based, Uncertainty Production

1. Introduction
One of the most challenging aspects of the industrial environment in the 21st century is the uncertainty of production. Production uncertainty is caused by manufacturing plants currently trend to be more flexible due to rapid changes in product mix and market demand. The company always tries to implement various layout configurations that are flexible enough to accommodate various production requirements [1].

Sethi and Sethi review extensively the uncertainty in manufacturing. According to Sethi, there are two types of uncertainty, namely uncertainty because of internal use and uncertainty due to external forces. Uncertainty due to internal use, such as equipment malfunctions, changing task times, queuing delays, rejections, and rework. Uncertainty due to external forces such as uncertainty in the level of demand, product prices, product mix, and others [2].

A problem in order to determine the department’s position properly so that the department does not overlap and at the same time several objectives of the layout can be optimized, this is called the Facility layout Problem. To solve this problem can be done with two approaches, namely Facility Layout Dynamic Problem and Facility Layout Stochastic Problem [3].
Zone-based facility layout is a facility layout where facilities are grouped into several zones based on functions with relatively fixed position then departments are assigned and arranged into the zones with the aim of minimizing the total cost of facility layout. The advantage of this zone-based facility layout is that changes in layout can be adjusted from one period to the next so that modifications to the arrangement are needed in the material handling system. By using zone-based layout in the context of the dynamic facility layout problem, changes in the material handling system can be carried out implicitly [4].

In order to develop a dynamic layout, the purpose of a facility layout design is not just one goal but can be carried out in several purposes called multi-objects. A set of several decision-making criteria, which deals with mathematical optimization problems involving more than one function the goal to be optimized simultaneously is called multi-purpose optimization. Optimal decisions must be taken with a trade-off between two or more conflicting goals. For example, the first goal is profit maximization, efficiency, etc. The second goal is to minimize costs, distance, routes, etc. With restrictions in the form of work area (length and width), flow of production processes, frequency and working time [5].

Challenges to zone-based facility layout with uncertainty conditions are as follows, (1) Need of an analysis to facilitate understanding the complexity of zone-based layout systems, (2) Manage uncertainties that come from the production system environment, (3) The need for Dynamic Multi-Objective design in zone-based layout with uncertainty conditions, (4) The need for strategies and scenarios including time windows, routes, costs, department width.

This research develops zone-based dynamic facility layout with multi-objective approach with dynamic considerations of the production area, production route, location, cost, multi-stage, work in process (WIP), and challenges to change in the complexity of zone-based eruption systems that have not been carried out in the previous research. The purpose of this research is to analyze the zone-based layout system, to analyze demand uncertainty affecting production, to develop a multi-objective model in a zone-based layout, to design a zone-based facility layout strategy and change in scenario.

2. Research Method
To analyze the problem, and determine the characteristics and methods that will be used in developing research on zone-based dynamic facility layout, a literature review is carried out by reviewing all articles related to the topic of facility layout, dynamic facility layout, zone-based, multi-purpose, production uncertainty, and others. The results of the review of the research articles are grouped based on the characteristics of the study and the methods used. Based on this grouping, it was concluded and determined the characteristics of the research that needed to be developed from this study. Then proceed with the determination of the system analysis and the proposed research steps.

2.1. Literature Review
Solving the problem of the layout of zone-based dynamic facilities (based-zone) is proposed using various appropriate methods such as heuristics, hybrid heuristics, and metaheuristics. By using a more realistic mileage, not the resultant square distance has traditionally been used in a more practical and realistic facility layout literature in layout blocks [4].

According to the research of Xiao, et al (2017) who developed the Problem Evolution Algorithm as a general solution approach to facility layout, through a combination with a linear program called FEA-LP. Computational experiments in the FLP benchmark case show that PEA-LP solves 9 problems from 11 problems with solutions that are better or equal to the previous solution in relatively short CPU times [1].

In considering the production line, it is faced with two types of uncertainty, namely environmental uncertainty and system uncertainty that can be difficult in its solution. To overcome difficulties and ambiguities, bootstrap techniques are used, to obtain reliable and reliable data, and fuzzy simulations for modeling and problem-solving. Then fuzzy numbers are obtained as production levels, which are very reliable and can be used in other decision areas [3].

The impact of environmental policy on production-inventory decisions affects the uncertainty of environmental demand and customers [6]. Problems of dynamic facility layout under uncertainty: evolutionary multi-purpose based Pareto-optimality. This study confirms that combining this approach
with a backward pass heuristic helps not only to improve an almost optimal solution but also to produce a Pareto optimal layout with better convergence and diversity [7].

Planning a dynamic multi-purpose layout from the construction site with the planning of Dynamic Construction Site Layout (DCLP) is a complex combinatorial and multi-objective optimization problem related to efficient temporary facility arrangement and varied project requirements [8].

Integrated Simulation-Based Optimization Techniques for Problem Layout Multi-Objective Dynamic Facilities with the power of simulation are further enhanced by applying experimental and regression design approaches. Meta-models to expand the implementation of the realized model. The meta-model that is designed is able to study the linkages between machines as input variables and the amount of interference that might be possible as an output variable [5].

A comprehensive prospect is taken by DFL to develop a multi-objective model. This model allows simultaneously for quantitative and qualitative analysis of dynamic facility layout problems [9]. A mathematical formula with a layout solution that changes according to changes in demand. The optimal procedure and heuristics are developed based on dynamic program formulations. The use of one of these approaches depends on the ability to solve static problems efficiently [10].

In Nayak's (2007) study, the development of a new tool "Dynamic From Between Chart (DFBC)", the formula for calculating costs, and the application of this tool to dynamic layout problems for various time periods for the continuous model layout. In this study, the application of DFBC to analyze the impact of new product/machine recognition and the elimination of products / machines that are between the time horizons are considered. DFBC's ability to overcome this scenario was evaluated using a case study [11].

An algorithm developed for dynamic single-row facility layouts. The test results using several hypothetical scenarios data show that the algorithm has a better performance to determine the length of time windows and the total costs generated [12].

3. Results and Discussion

3.1. Literature Review Grouping

The output of the research tabulation based on the discussion above can be concluded that:
- Grouping in terms of the method used

The research grouping base on the method used can be seen in Table 1. and Figure 1. below

| Num. | Research       | Total |
|------|----------------|-------|
| 1.   | Heuristic      | 36    |
| 2.   | Meta Heuristic | 10    |
| 3.   | Dynamic Model  | 4     |
| 4.   | Robust         | 8     |
| 5.   | Optimization   | 5     |

Figure 1. Research Grouping Chart Based on Method
The output of the research tabulation based on the discussion above can be concluded that:
- Grouping in terms of the parameter used

The research grouping base on the parameter used can be seen in Table 2. and Figure 2. below.

### Table 2. Research Grouping Based on Parameter Recapitulation

| Num. | Research               | Total |
|------|------------------------|-------|
| 1.   | Zone-Based             | 3     |
| 2.   | Planar                 | 1     |
| 3.   | Multi-Objective        | 11    |
| 4.   | Multi Floor            | 3     |
| 5.   | Uncertainty            | 8     |

### Figure 2. Research Grouping Chart Based on Parameter

#### 3.2. Future Research Formulation

Based on the review above it was found that further research (future research) in the field of Dynamic Facility Layout Problems is as follows.

1. Approach to the development of future methods, namely the Heuristic and Metaheuristic approaches by considering the uncertainty of time, dynamic, flexibility, and layout.
2. Consideration of complexity

To add complexity to the problem, several parameters were determined based on the literature review, namely:

a. Route
b. Efficiency
c. Cost
d. Department location and area
e. Multi-stage
f. Multi-objective
g. Production level
h. Alley
i. Real-time
j. Process Complexity
k. Time windows
l. Work in Process
3.3. Proposed Research Framework

Research methodology is a scientific process or method to obtain data that will be used for research purposes. This proposed research is divided into four approaches which can be seen in the following framework.

**Figure 3. Dynamic Facility Layout Problem Since 1986-2017**

**Figure 4. Research Methodology Framework**
3.4. System Analysis
System analysis is the translation of a complete information system into various parts of the component with the aim of being able to identify and evaluate various kinds of problems or obstacles that arise in the system so that later can be carried out countermeasures, improvements and also development [13]. The method used is the Analytical System Entity Construct. In system engineering, there are limits to acceptable inputs and acceptable outputs.

- Stakeholders
- Resources
- Control

![Analytical System Entity Construct](image_url)  
**Figure 5.** Analytical System Entity Construct [14]

3.5. Production Uncertainty Analysis
Sethi and Sethi review extensively the uncertainty in manufacturing. According to Sethi, there are two types of uncertainty, namely uncertainty because of internal use and uncertainty due to external forces. Uncertainty due to internal use, such as equipment malfunctions, changing task times, queuing delays, rejections, and rework. Uncertainty due to external forces such as uncertainty in the level of demand, product prices, product mix, etc. [2].

Forecasting is the use of data or information to determine future events, in the form of calculations or forecasts from past data and other information to research in advance of the forecast. The forecasting steps are as follows:
1. Determination of Objectives
2. Relevant Theory Selection
3. Proper Data Search
4. Data Analysis
5. Estimating the initial model
6. Model Evaluation and Revision
7. Presentation of Provisional Forecast to Management
8. Last Revision
9. Distribution of Forecasting Results
10. Determination of Monitoring Steps

3.6. Multi-Objective Dynamic Facility Layout Development
Multi-objective optimization (also known as multi-purpose programming, vector optimization, multi-criteria optimization, multi-attribute optimization or Pareto optimization) is a set of multiple decision-making criteria, which deals with mathematical optimization problems that involve more than one objective function for optimized simultaneously.

The stages/phases of the development of the Multi-Objective Model are as follows.
1. Defining the scope of the problem
2. Model formulation
3. Solution model
4. Validity model
3.7. Facility layout Change’s Scenario and Strategy

Strategies and scenarios are carried out after a multi-objective dynamic model solution is carried out using a model simulation approach. The purpose of the simulation model is to get the behavior of changes to the resulting layout. If the input to the simulation changes, the dynamic layout also changes so that changes in the variable and its destination occur.

3.8. Research Location

The research was carried out on companies that were volatile, such as factories, furniture, electronics, and others.

4. Conclusion

Emphasis on the development of industry in this era leads to changes in zone-based dynamic facility layout with a multi-objective approach taking into account the dynamism of the area, production, production routes, location, costs, multi-stage and challenges to changes in layout complexity that has not been done by researchers previous. Further research formulation in the field of dynamic facility layout problem is carried out with the approach of future method development, namely heuristic and metaheuristic approaches by considering uncertainty of time periods, dynamic, flexibility and layout, and the complexity considerations as mentioned above. This research was conducted through four stages consisting of system analysis (entity analysis system construct), uncertainty analysis (forecasting method), dynamic facility multi-objective layout, and strategy and change scenario (simulation).

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References

[1] Xiao 2017 *A Problem Evolution Algorithm With Linear Programming for the Dynamic Facility Layout Problem-A General Layout Formulation* (China: Beihang University)

[2] Sethi A K & Sethi S P 1990 *Flexibility in Manufacturing: A Survey. The International Journal of Flexible Manufacturing System*, 2, 289-328.

[3] Konak Sadden Kulturel 2007 *Approaches to Uncertainties in Facility Layout Problem: Perspectives at the Beginning of the 21st Century* USA

[4] Konak K Sadan 2017 *The zone-based dynamic facility layout problem Management Information Systems, Penn State Berks, Reading, PA, USA*

[5] Pourhasan Mohammad Reza and Sadigh Raisi 2017 *An Integrated Simulation-based Optimization Technique for Multi-objective Dynamic Facility layout Problem* (Iran: Islamic Azad University)

[6] Kogan Konstantin Beatrice Venturi and Matan Shnaiderman 2016 *The effect of uncertainty on production-inventory policies with environmental considerations* IEEE Transactions on Automatic Control DOI 10.1109/TAC.2017.2691302

[7] Ripon Kazi S N 2011 *Dynamic facility layout problem under uncertainty: a Pareto-optimality based multi-objective evolutionary approach* Research Article Norway: Cent. Eur. J. Comp. Sci. 1(4) 375-386

[8] Farmakis Panagiotis M 2017 *Dynamic Multi Objective Layout Planning of Construction Sites* (Greece: University of Patras)

[9] Emami Saeed 2013 *Managing a New Multi-Objective Model for the Dynamic Facility Layout Problem* (Iran: Isfahan University of Technology)

[10] Rosenblatt Meir J 1986 *The Dynamics of Plant Layout Management Science* Jan 1986; 32, 1; ABI/INFORM Collection pg. 76.

[11] N Nayak Chandan 2007 *Solutions to dynamic facility layout problems: Development of dynamic from Between Chart (DFBC) and it’s application to continuous layout modeling*
(Department of Industrial and Manufacturing Engineering and the faculty of the Graduate School of Wichita State University)

[12] Yogaswara Yogi 2015 *Dynamic modified spanning tree algorithm for single-row dynamic facility layout problem* (Industrial Engineering Department, Pasundan University)

[13] R A Darajatun 2017 *Warehouses Information System Design and Development* IOP Conference Series: Materials Science and Engineering

[14] Wasson C S 2016 *System Engineering : Analysis, Design, and Development* (Wiley Series in System Engineering and Management)