Development of Risk-Based Work Breakdown Structure (WBS) Standard to Improve Scheduling Planning of Airport Construction Work

Daniel Sitohang¹, Yusuf Latief¹, Leni Sagita Riantini¹

¹ Civil Engineering Department, Indonesia University, Depok, Indonesia

Abstract. The airport development project is included in the list of National Strategic Projects of Indonesia stipulated in Presidential Regulation no.58/2017. The Government is committed to realize the economic independence by increase infrastructure development and one of them by moving the economic sector that must be supported by one of which is the construction of the airport in areas that can spur economic impact. However in practice, there is often a delay in the process of implementing airport construction that negatively impacts stakeholders related to the project. So it takes good and correct airport project management to eliminate this phenomenon. Work Breakdown Structure (WBS) is a project activities decomposition of which are broken down into several work elements based on the hierarchy. WBS makes project management better so that risks to time performance weakness can be anticipated and managed at the resources level. This study aims to develop risk-based WBS standards to improve airport project construction time performance. The results of this study are WBS standards, implementation methods, activities, potential hazard risks, scheduling planning using risk-based WBS standards, WBS dictionaries and WBS checklists on airport construction work, as an effort in preventing, reducing or eliminating the potential events resuting in delays.

1. Introduction

Airport is an area on land and / or waters with certain limits used as a place for aircraft to land and take off, boarding passengers, loading and unloading of goods, and places of intra and intermodal transport, which are equipped with flight safety and security facilities, as well as basic facilities and other supporting facilities [10].

The construction of airports or airports is included in the list of National Strategic Projects regulated in Presidential Regulation number 58 of 2017, namely realizing economic independence by moving the strategic sectors of the domestic economy to encourage the Ministry of Transportation to be able to build airports in regions that can spur the economy. The Ministry of Transportation's Airport Director on May 22 2015 targets that the government will build 60 airports by 2030 so that the total number of airports in 2030 reaches 299 airports [3].

The Airport Project is a project that has a very high level of complexity, so that in its implementation, if it is not managed rigorously and well it will have effects that affect various aspects, one of which is project delays that are reviewed in this study. Some media sources show frequent delays in the implementation of airport physical work. Several cases of airport development delays, namely Blimbingsari Airport were delayed by 2 months resulting in a loss of 14.5% of the contract value. Terminal 3 Ultimate of Soekarno Hatta Airport was 2.5 months late, which resulted in the government's plan to withdraw and there were many other delays. Project delays are a phenomenon that is very
frequent and almost related to almost all projects in the construction industry. This trend is more severe in developing countries [1].

Many factors are causing delays, some factors include poor management practices [6], financial problems of the project owner and likewise with contractors, poor field management by contractors, poor weather conditions, modification of contracts, incomplete documents / slow in making decisions, lack of labor and material in the field, construction errors and repairs / repetition work [9]. From this we find that a serious effort is needed in scheduling.

The main purpose of scheduling is to coordinate activities to prepare the project with the best time, the smallest cost and the smallest risk [5]. Clearly defined activities in accordance with the settlement hierarchy will help the project team to plan project scheduling as well as possible. This activity is defined in the Work Breakdown Structure (WBS).

Work Breakdown Structure (WBS) is a hierarchy of project activities that are broken down into several elements - smaller elements of work that relate to how the work will be carried out and show how the costs will be taken by the project and how data can be summarized and reported more effectively [4]. The foundation in forming WBS is the project requirements which if done will produce deliverables that are in line with the expectations of all stakeholders [11]. The project requirements are defined and controlled in the project scope management planning process. This activity is identifying what jobs are included and not included in the project. This activity also defines work, what work is needed in the project to be further detailed into work package units.

In the planning of a project, the design planner has decomposed the activity to the part that can not be further divided, namely the resources, but in practice, the construction contractor, the implementing contractor, has its own view of each activity that may differ from the concept of a planner consultant, this will result in wasted time to synchronize perceptions until the reworking takes place. So, even though the project is a unique activity, the researcher feels that it is necessary to make a WBS standard so that the perception of implementing the airport project becomes uniform. So that the results of this study can be a framework that can be developed according to the specifications and requirements of the project owner.

2. Research Objectives

The objectives of this research are to create WBS standards for airport construction, to identify the working method for each airport construction work package, to identify the activities of each airport construction work package, to identify the resources for each airport construction activity, to identify the risk that come from work packages, activities and resources that affect the time performance of airport construction work, to develop of risk-based WBS standards used to develop scheduling plans for airport construction work, to create WBS dictionary based on the needs used to develop a scheduling plan on airport construction work, and to create WBS checklist from every WBS level to the work packages.

3. Literature Review

3.1. Work Breakdown Structure for Airport Construction

The WBS matrix is useful for improving interface management in projects. Increasingly detailed construction will result in better communication between designers and constructors regarding the specific requirements and constraints for construction incorporated into the design, with the same principle can be generalized that there is better communication at the stage of the construction project between design, equipment and equipment, procurement, transportation, delivery, installation, and such tests with handover activities [2].

The basis for the development of WBS for the airport was obtained from various BoQ various airport development projects and adapted to Undang – Undang No. 1 Tahun 2009 about Penerbangan, Surat Keputusan Menteri Perhubungan No. KM 48 tahun 2002 about Penyelenggaraan Bandar Udara Umum, Peraturan Pemerintah No. 70 tahun 2001 about Kebandarudaraan, Peraturan Menteri Perhubungan No. PM 77 tahun 2015 about Standarisasi dan Sertifikasi Fasilitas Bandar Udara, Surat Keputusan No. 347 Tahun 1999 about Standar Rancang Bangun dan/atau Rekayasa Fasilitas dan Peralatan Bandar Udara, to see the structure of airport components.
3.2. Risk Management
Project risk is an uncertain event or condition which, if it appears, has a positive or negative effect on one or more project objectives in relation to the scope, scheduling, cost and quality of the project [14]. Project Risk Management is a process included in it, planning risk management, identification, analysis, response plans and risk control in a project [12]. A simpler WBS enables more effective and efficient project control. A more logical and accurate schedule provides better risk identification and assessment of the impact of time and costs [8]. Risk response will be an additional activity in the WBS so as to provide a measurable and managed control on the project.

3.3. Scheduling Planning
Scheduling is the process of determining the start and finish dates [12] which requires an analysis of the activity schedule, duration, resource requirements and schedule constraints to create a project schedule [13] where operations / implementation are determined and sorted and combined as a whole to get the settlement time whole. [7]. The purpose of scheduling is to provide a roadmap that represents the submission of project scope over time as defined by the project team.

3.4. WBS Dictionary
The WBS dictionary is a brief description of each work package that includes an explanation of the WBS code, WBS level, job responsibilities, description of work packages, submissions, references or work activities and resources. The WBS dictionary uses a format that shows hierarchical relationships between activities.

3.5. WBS Checklist
WBS Checklist is a form that contains an inspection guide from each level of the WBS to the work package. This checklist is useful for measuring the compatibility of WBS by referring to the details of activities that exist at each level of the WBS from the WBS diagram, and based on the description of each WBS dictionary activity.

4. Methodology
This research was conducted with a qualitative approach to answer the research objectives. Surveys and interviews were conducted using a structured questionnaire for airport construction experts with more than 20 years of experience. The research flow diagram can be seen in Figure 1.

Figure 1. The Research Flow Diagram
5. Result and Discussion

Based on a literature review on airport construction and 15 (fifteen) previous project data, it was found that airport construction work was categorized into 6 (six) facilities, namely air facilities containing Runway, Taxiway, Apron, RESA, Stopway, Clearway, Flight Accident Aid and Fire Extinguisher, Equipment for Visual Landing Equipment, Markings and Signs. Aviation Communication Facility which contains Aviation Communication System Equipment. Flight Navigation Facility that contains the Navigation System Equipment. Land-side Building Facilities containing Passenger Terminal Buildings, Cargo Terminal Buildings, Aviation Operational Buildings, Air Traffic Control Towers (ATC), Meteorological Systems, Access Roads Depots on Airfuel Refueling, Administrative Buildings and Offices, Parking of motorized vehicles, Markings and Signs, Power House, Pump House and Water Tank, Waste Processing Building, Clean Water Supply System Equipment, Electrical Energy Supply System Equipment. Airport Support Facilities that can be categorized as compulsory or become additional according to the project owner's policy. Each of these categories has a WBS that follows Figure 2. In Figure 2, one of the occupational categories is shown, namely the Passenger Terminal Building.

![Figure 2. Work Breakdown Structure Diagram](image)

Level 1 is for the project name, level 2 is the Work Section which consists of Preparation, Architecture, Structure, Interior, External Works, Mechanical, Electrical, and Special Equipment Works. Level 3 is the Work Sub-Section. Level 4 is a Work Package. Level 5 is an Activity and level 6 is a Resource consisting of Material, Equipment & Labor. Level 1 is appointed from one component of the Airport facility. This is done because the projects inside the airport are so complex that the implementation is often carried out in a special way, for example only the construction of a terminal building, or just the development and construction of runways, or taxiways, and so on. But construction practitioners can also combine some of these WBS standards into a complete airport project unit if it is needed for the management of the airport project as a whole.

Identification of any risks that have the potential to slow down airport development obtained from literature studies which are then verified, clarified and validated for content and construction for experts. Experts were asked whether they agree or disagree with these risk factors and input on each of the risk factors, impacts and causes. In addition, experts are required to provide additional risk factors. These risk factors will be analyzed using a risk matrix where the risk score can be calculated by following the following formula:
\[ R = P \times I \]  
(1)

Where, \( R \) = risk factor, \( P \) = probability dan \( I \) = impact.

**Table 1. Risk Level Matrix**

| Impact   | Very Low | Low | Med | High | Very High |
|----------|----------|-----|-----|------|-----------|
| Frequency | 5        | 10  | 15  | 20   | 25        |
| Frequent  | 4        | 8   | 12  | 16   | 20        |
| Somewhat Frequent | 3    | 6   | 9   | 12   | 15        |
| Occasionally | 2   | 4   | 6   | 8    | 10        |
| Rare      | 1        | 2   | 3   | 4    | 5         |

Here are some details on each of the categories:

1. High: the risks that fall in the cells marked with red color, are the risks that are most critical and that must be addressed on a high priority basis. The project team should gear up for immediate action to eliminate the risk completely.
2. Moderate: the risk falls in one of the yellow cells, may affect time performance, handled directly at the project level (project manager).
3. Low Risk: the risks that fall in the blue cells slightly effect on cost performance and handled directly by engineer or related parties.

Next step is to create potential risks and look for potential risk sources that are very influential during project implementation, so that the results obtained are scheduling planning that anticipates delays (column 2), activities (column 3) and risk control (column 9). The results follow table 2.

**Table 2. Risk Respon Planning**

WBS Dictionary is made by following the format in figure 3. Figure 3 is one of the WBS dictionaries for one of the jobs of the airport facility component, namely for the passenger terminal building.
Figure 3. WBS Dictionary

The WBS checklist is created following the format in figure 4. Figure 4 is one of the WBS checklists for one of the components of the airport facility, the Passenger Terminal Building.

Figure 4. Checklist WBS

5.1. Validation

Validation is carried out on the overall results of the study, there are:

a. At the stage of the WBS development results,

b. At the stage of identifying the highest risks related to the implementation of airport construction,

c. At the stage of the results of the corrective and preventive response activities to the highest risk.

d. At the stage of reviewing the overall research results.

The validation phase is carried out to experts who have experience in implementing airport construction. Experts have positions ranging from vice president of civil engineering, staff with 35 years of experience in infrastructure including airports, experts in aviation telecommunications and navigation with 34 years of experience, and project managers with more than 20 years of experience in airport implementation. Shown by the following figure 5.
5.2. Risk Variables Survey
The survey was conducted to get the highest risk identification distributed to construction actors located in Jakarta, but had and / or were working on projects in several places in Indonesia. Respondents who were targeted were airport construction actors with work experience in the field of implementing airport construction projects on airside and landside for at least 3 years. Questionnaire data was distributed to 60 people, returned 51 data, and invalid data numbered 5 data, so the data that could be used as material for analysis were 46 questionnaire data. The profile of the respondents can be seen from table 3, as follows.

Table 3. Profile of Respondents

| No | Description                                      | Total |
|----|--------------------------------------------------|-------|
| 1  | **Position**                                     |       |
| 1  | Project Manager                                  | 8     |
| 1  | Construction Manager                             | 2     |
| 1  | Quality Control Coordinator                      | 2     |
| 1  | Engineer                                         | 12    |
| 1  | Supervisor                                       | 16    |
| 1  | Manajer Proyek - Above 20 Years Experience       | 3     |
| 1  | Manajer Proyek - 6 - 10 years Experience         | 6     |
| 1  | Manajer Proyek - 11 - 15 years Experience        | 6     |
| 1  | Manajer Proyek - ≥ 16 years Experience           | 6     |
| 2  | **Institution**                                  |       |
| 2  | A (Airport Owner)                                | 10    |
| 2  | B (Construction Management)                      | 6     |
| 2  | C (Contractor)                                   | 22    |
| 2  | D (Contractor)                                   | 4     |
| 2  | E (Contractor)                                   | 4     |
| 3  | **Work Experience**                              |       |
| 3  | ≤ 5 years                                        | 16    |
| 3  | 6 - 10 years                                     | 10    |
| 3  | 11 - 15 years                                    | 16    |
| 3  | ≥ 16 years                                       | 4     |
| 4  | **Education**                                    |       |
| 4  | Vocational/Diploma                               | 4     |
| 4  | Bachelor degree                                  | 36    |
| 4  | Master degree                                    | 6     |

From the literature search results and has been validated by experts to be distributed to respondents, 59 risk variables were found to influence time performance. Then from the results of the distribution of questionnaires obtained the dominant risk data shown in table 4 below.
### Table 4. Higher Risk level Identification

| No | Risk Variables                                                                 | Rank |
|----|-------------------------------------------------------------------------------|------|
| 1  | There is a mismatch of construction / implementation methods that are applied with planning | 1    |
| 2  | The planned material is not available in the work area                         | 2    |
| 3  | Many changes in design, image, specifications and scope of work packages during the project | 3    |
| 4  | Errors in planning implementation / construction methods                       | 4    |
| 5  | The Consolidation Settlement method is not appropriate for weak soil           | 5    |
| 6  | Material delivery is delayed from the planning schedule                        | 6    |
| 7  | Submission of change request work from main contractors to subcontractors for the purpose of pricing is not implemented quickly | 11   |
| 8  | The consultant is late in giving approval and permission to contractor activities | 16   |
| 9  | The superintendent is late in giving work instructions                         | 19   |
| 10 | Equipment has been damaged                                                      | 8    |
| 11 | Unscheduled use of equipment / poor scheduling of equipment                    | 15   |
| 12 | Labor productivity is lower than needs                                         | 14   |
| 13 | The number of workers is inadequate from what is needed / planned              | 17   |

### 6. Conclusion

The results of the WBS standard manufacturing process concluded that airport development was categorized based on facilities at the airport, namely airport construction work categorized into 6 (six) facilities, namely air facilities containing Runway, Taxiway, Apron, RESA, Stopway, Clearway, Flight Accident Aid and Fire Extinguisher, Visual Landing Equipment, Markings and Signs. Aviation Communication Facility which contains Aviation Communication System Equipment. Flight Navigation Facility that contains the Aviation Navigation System Equipment. Land-side Building Facilities containing Passenger Terminal Buildings, Cargo Terminal Buildings, Aviation Operational Buildings, Air Traffic Control Towers (ATC), Meteorological Systems, Access Roads Depots on Airfuel Refueling, Administrative Buildings and Offices, Parking of motorized vehicles, Markings and Signs, Power House, Pump House and Water Tank, Waste Processing Building, Clean Water Supply System Equipment, Electrical Energy Supply System Equipment. Airport Support Facilities.

The results of the WBS development show that if the airport as a level 1 project will form a WBS level into 5 levels of WBS elements and 2 levels of WBS that are derivative. Level 1 to level 5 is developed from government regulations on airports and data on previous projects to identify work packages (level 5), while 2 levels of WBS (activities and resources) that are derivative are dependent on the requirements inherent in airport projects. 5 level elements of the WBS are airports as level 1 (project name), level 2 is airport facilities, level 3 is work clusters (structure, architecture, mechanical, electrical, special equipment and landscape), level 4 is type of work and level 5 is a work package. The method of doing work in the fulfillment of work packages (level 5) is called an alternative design / method that becomes an alternative in carrying out any level 6 (activities) to meet the success requirements of the work package (level 5). After selecting the method used in the implementation of the work package, the logic of activities (level 6) will be produced which must be carried out in accordance with the applicable implementation standards. Level 7 is the resources needed to carry out activities that are divided into human resources, equipment resources, and material resources.
The dominant risk obtained from the research results is 13 risks selected from the 6 highest risks and 2 risks representing each category.

The risk response to the project delay will be the input of several groupings as follows:
1. Being a new activity at the WBS concerned,
2. Become additional activities at other WBS (preparation work, etc.),
3. Become additional input on project management,
4. Become additional to the job requirements, and
5. Affect the WBS coefficient.

Scheduling Planning can be developed through work order based on the risk-based WBS Standard to the time of delay so that the project can be managed to the level of resources.

This research is expected to be able to fill the shortcomings found in the WBS phenomenon which is rarely made in a formal form so as to make the management of the scope not optimal which has an impact on project performance that is not optimal. It is expected that through WBS standardization, it will be obtained as follows but are not limited to:
1. WBS developed can produce management to the level of resources (resources).
2. The WBS developed can equalize stakeholder perceptions of the scope of infrastructure work so that there is conformity to project implementation in terms of the owner, planner and project implementer so as to minimize the failure of communication management.
3. WBS that are developed into formal information that can be used in scheduling which has accommodated all the scope of the airport.
4. WBS becomes a tool in mapping the performance of each work package, type of work, work cluster, and finally at the project level itself.
5. This standard WBS can be a guide in making WBS airports in a formal form.
6. WBS that can be formally made will estimate the cost to be accurate because it does not only focus on items in the Bill of Quantity, but also includes activities that exist within the Term of Reference (TOR), thus providing a suitability for the tasks that might be missed in making WBS based only Bill of Quantity.
7. Jobs that do not enter the Bill of Quantity can be calculated into project scheduling, so that scheduling can be fully developed from the WBS.
8. Provide a perspective of defining work items between the same parties because they refer to standardized WBS so that they are the same in determining the critical path.
9. WBS that are formed in a formal form make identification of risks better.
10. Important activities are not missed. This is because there has been a logical solution to the tasks in the project based on BoQ data, TOR, and Government Regulations and validated by airport construction experts.
11. Provide input to the project leader in determining important tasks in completing work packages so as to make identification of resources and so that scheduling becomes more accurate.
12. Making communication and coordination better because of the understanding of the scope of various project stakeholders (stakeholders). Input for communication management is the scope of the project in the project management plan.

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