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Identifying the Criteria Used for ESTABLISHING WORK PACKAGE SIZE FOR PROJECT WBS

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ABSTRACT

A successful completion of a project entails the proper use of project management. Project management includes different areas of which scope, as a major one, requires identification of the work that should be completed in a project. This is greatly facilitated by the use Work Breakdown Structure (WBS), of which Work Packages (WPs) are the basic components. This study aimed at identifying major criteria used by project managers, to establish the work content of the WPs included in the project. The study is based on analysis of 25 projects by their project managers. As part of the analysis, project managers requested to analyze a sample of WPs from each project generating a total of 219 WPs that were analyzed. Five major groups of WPs nature were identified, namely: design, testing, management, production, and procurement. Project managers were asked to identify the rules used by them to stop further decomposition of WPs. Six major rules were identified, which captured 93% of the rules used by project managers in establishing the WP size.

1. Introduction

The PMBOK *(2013)*, identified ten Project Management *(PMgt)* areas that a project manager should be familiar with, in order to bring the project into a successful completion. There is sufficient empirical evidence concerning the positive correlation between those areas and project success *(see Papke-Shields et al (2010)*, Cooke-Davies *(2004)*, Thomas & Mullaly *(2008)*, Asad & Pinnington *(2014)*).

Papke-Shields et al *(2010)* also pointed out that out of the ten knowledge areas, the greatest use of PMgt practices are associated with time, scope, and cost. Practices associated with integration, human resources, and procurement are utilized moderately, and those associated with communication, quality, and risk are used less frequently. Kwak and Ibbs *(2000)*, looking at PMgt maturity in 38 organizations, had similar findings showing that time, scope and cost obtained the greatest emphasize as compared to quality and risk. This paper concentrates on Scope, which belongs to the PM knowledge areas with greatest use by practitioners.

The knowledge area of "Scope", includes the important process of establishing the project content via the WBS. The relative importance of WBS has been emphasized all along the history of PMgt. For example, Bachy & Hameri *(1995)* stated that the "Work breakdown structure is the backbone of proper planning, execution and control of a project". Taxén & Lilliesköld *(2008)* and Kolltveit et al *(2007)* indicated that WBS is considered a foundation concept of PM and is an essential first step in the project planning process. A similar comment concerning the importance of WBS to project success was also made by Serrador & Turner *(2015)* who conducted a survey that investigated the linkage between project planning and project sucess.

Generating WBS requires a disaggregation of the total project content into manageable work packages *(WPs)*. A WP is defined as the lowest level of WBS for which cost and duration can be estimated and managed. The end result of a WP should be of a deliverable nature. A deliverable may have different shapes, such as a produced item, a document, a software package, or a repaired item. Since the set of WPs contained in a WBS plays a central role in representing the project's scope, it is important to define them in a manner that will best facilitate the planning, execution and control of each single WP and the project as a whole. Proper management of a project can be achieved only if the WBS was properly decomposed into single WPs and that each WP is properly managed.

The concept of life cycle management, which requires a management effort, is very relevant to a WP, since each has to be planned, executed, controlled, delivered to a customer, and maintained throughout its life. In this context, decomposition of a project into smaller and more numerous WPs increases the workload on the project manager and on the project team. On the other hand, it simplifies the planning, execution, and control of each WP, although it may complicate the integration. Some organizations have general guidelines for the recommended size of WPs. Guidelines are typically expressed in terms of effort *(e.g., person-hours, person-days, dollar value)* or in terms of elapsed time *(e.g., days, weeks)*. Other considerations may include scheduling needs, control requirements, documentation abilities, and cost calculation.

In-spite of the importance of a proper WP content definition, there are very few articles which focused on the subject matter. Raz & Globerson *(1998)* discussed the importance of proper definition of a WP and the effect of its size on the overall issue of PM. Or, Vanhoucke *(2012)* who claimed that drilling down to the WP level of a project WBS, can trigger corrective action for perceived risk at an early stage. Gao and Xu *(2014)* comment that there is a need for research concerning the development of decomposition guidelines. A similar comment was also made by Siami-Irdemoosa et al *(2015)*, who developed WBS for underground tunnels projects

Informal interaction of the authors with many project managers, brought to the conclusion that the issue concerning the definition and management of a WP is of great importance, but no commonly accepted methodologies is available. This lack of formal methodology may have a stronger impact in the future, as projects become more complex. Therefore, in this paper, we aim at exploring existing methodologies used for establishing the WP size.

2. The study

General

The goal of this study aimed at identifying the reasons that stopped project managers from further decomposing work packages of a project, into smaller work packages. Thus, generating the WPs size perceived to be the most effective ones.

The study was administered in a large organization that deals with developing and producing high-tech. systems. Twenty five project managers *(PMs)* were selected. Typical background of those PMs was a first degree in Industrial Engineering. They received an explanation concerning the purpose of the study and a designated PM professional helped them to fill up the structured questionnaire *(see Appendix A)*. Each participant was asked to describe his professional background, to select and describe a project

which was recently completed successfully, and select a few WPs *(8 to 10)* belonging to that project.

The 25 projects included in the study, came from areas such as communication, electronics, and software. The projects' budget, ranged from few millions and up to 350 million dollars, with a median of around 25 million dollars. Projects' durations were within the range of 1-6 years, with 65% of the projects lasted within the range of 12-24 months.

A list of possible criteria to stop WP decomposition, was first composed. The list was collected via interviews and discussions with professional PMs, as well as from literature reviews *(e.g. Raz & Globerson 1998)*. Participants of the study were then asked to either use the generated list when analyzing the selected WPs, or add other criteria.

Nature of the Work Packages

Each of the 25 PMs was asked to randomly select a few WPs from a project managed by him, and analyze them. Altogether, 219 WPs were selected and analyzed, an average of around 9 WPs per project. Exhibit 1 presents the nature of the selected WPs.

Nature of WP	No	%
Design	114	52.0
Testing	39	17.8
Management	30	13.7
Production	24	11.0
Procurement	12	5.5
Total	219	100.0

EXHIBIT 1. *Distribution of the nature of the selected WPs*

As can be observed from Exhibit 1, majority of the WPs are of a design nature. It is not of a surprise since a significant portion of the organization's business deals with new product development.

The second common WPs category is "testing". It is not of a surprise as well since developing new product always calls for intensive testing. The third WPs category is "Management". "Management" WPs are those that the PM is typically responsible for their execution, their work content requires integration among different organizational units, and quite frequently customer's involvement and approval is required as well. It is typically related to the content of work specified in the Statement of Work *(SOW)* document and consists of a combined effort of resources of different nature. An example of such a WP is "proof of capability of product XX". Another example is "Production Readiness Review *(PRR)* surveys".

The nature of "Production" and "Procurement" WPs is self-explained and do not require further explanation.

Criteria used for stopping

As described above, participants were requested to specify the criterion used to decide when to stop further decomposition of each WP. They were able to select criteria of the following list, or to suggest their own:

- Organizational unit responsibility: The WP decomposition has stopped since it fits an organizational unit.
- Deliverable basis: The WP has a clear deliverable that can be transferred to a customer.
- Scope of work: The WP fits the description of a specific scope requirement, as defined by the customer (e.g., in the contract).
- Schedule estimation: The present size of the WP is at a level which allows reliable estimation of its duration.
- Risk management: The WP fits the resolution needed for effective risk management
- Cost estimation: The present size of the WP is at a level where it can be priced easily.
- Specific organizational guidelines: Each WP is created based on fixed organizational guidelines. Please detail those guidelines.
- Select and specify another criterion.

The following are two examples that demonstrate the use of the above criteria.

- **Example 1:** The use of an "organizational unit responsibility" criterion, for WPs included in an electronic device development project. The organization, in which the project is undertaken, has a development division which includes electrical design and mechanical design departments. The project manager in charge of the project, elected to divide the design work into two WPs, one that includes the electrical design and the other that includes the mechanical design. Each was assigned to the relevant organizational unit.
- **Example 2:** The use of the deliverable based criterion, for WPs included in an aviation project. Two of the WPs required were: maintenance training kit, and technical manuals. The project manager decided not to further subdivide each WP into lower levels components (e.g. mechanical, electrical, etc.).

The above criteria were used by all the PMs, for all the WPs. Exhibit 2 presents the frequencies of which different stopping criteria of stopping further decomposition of WPs, were used as a function of the nature of the WP.

From Exhibit 2 it emerges that the following criteria used for stopping further division of WPs are the most common ones: organizational unit responsibility, schedule estimation, and Scope Of Work *(SOW)*.

It makes sense that "organizational unit responsibility" is the leading criterion. This is so since for an effective management and control of a project, a PM strives for a clear assignment of a WP to a specific organizational unit that can be responsible for the delivery of whole WP content, rather than to continue to subdivide it. The superiority of the stopping criterion based on organizational unit responsibility is emerging as superior for the studied set of WPs of design and testing nature. The last conclusion was also verified by a chi square test, with 90% confidence level.

It seems obvious that a design WP will be assigned to a design organizational unit. However, this WP can be further subdivided due to other criteria such as "time", "schedule", or "risk"

As can be observed from Exhibit 2, only 6.8% of the WPs used "other" stopping rules rather than the listed ones. It means that the suggested list of stopping criteria were relatively conclusive for the set of WPs used in this study.

Another important issue to investigate with regard to WPs, is their size. Exhibit 3 presents statistics concerning the distribution nature of the budget assigned to the WPs, for different criteria. WP budget is expressed as a ratio from the total project budget to which the WP belongs to, for different stopping criteria. For example, for the "organizational unit" criterion, the average proportion of WP budget to the total project budget is AVG=0.02, with a standard deviation of STD=0.04 and a coefficient of variation of COV=STD/AVG=0.52.

AVG= 0.02 means that the average budget of WPs belonging to this group is 2% of the total project's budget. In other words, there are around 50 WPs on a project, if all of its WPs belong to the "organizational unit" group. On the other hand, the highest average belongs to the "cost estimation" group of WPs and is AVG= 0.11, generating a WBS with around 9 WPs **(Exhibit 3)**.

It becomes obvious that the WBS used for the sampled projects was not too detailed; leaving the parties responsible for each single WP, to further break it down into lower levels WP's. A major reason for the relatively law number of WPs per project was due to the fact that a significant portion of the WPs was assigned to subcontractors, who treated each large WP as a project by itself.

As was demonstrated above, the COV *(COefficient of Variation)* variable is calculated by the ratio of standard deviation to the average. It is a measure of dispersion of set of numbers and reflects the intensity of variation around the average. For example, the COV for the cost estimation criterion obtained the highest COV, meaning that WPs used cost estimation as the stopping criterion, obtained the greatest dispersion concerning their size.

As was mentioned in the previous paragraph, WPs that use cost estimation criterion as the stopping rule tend to be significantly larger than the other ones, and probably they are executed via outsourcing. In order for the subcontractor to which the WP was allocated to, to execute it, the WP assigned should probably be subdivided further into smaller WPs. This multi-layer of WBSs is presented in Exhibit 4.

Nature of WP	Stopping criterion							
	Org.	Sched.	SOW	Del.	Risk	other	Cost	Total
Design	49	15	11	20	10	9	0	114
Management	0	4	14	0	6	0	6	30
Procurement	0	7	0	1	1	0	3	12
Production	1	7	3	6	1	2	4	24
Testing	11	8	6	3	5	4	2	39
Total	61	41	34	30	23	15	15	219
Total %	27.9	18.7	15.5	13.7	10.5	6.8	6.8	100%

EXHIBIT 2. *Frequency of stopping WP decomposing criteria, as a function of the WP nature*

Stopping criteria	WP budget / project budget		
	Average	STD.	COV
organizational unit	0.02	0.04	0.52
cost estimation	0.11	0.13	0.81
schedule estimation	0.08	0.13	0.59
deliverable basis	0.03	0.05	0.64
SOW	0.03	0.05	0.65
risk management	0.06	0.11	0.55
Other	0.04	0.02	1.58

STD – STandard Deviation, COV - COefficient Of Variation

EXHIBIT 3. *Statistics concerning the ratios of WPs budget, to projects' budget, of which they belong to, for different stopping criteria.*

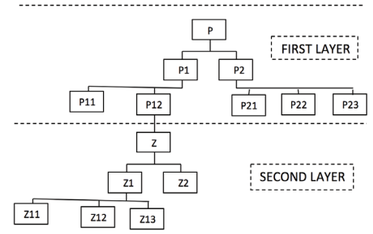

EXHIBIT 4. *Multi-layers of WBSs*

The above chart demonstrates the WBSs layers; the main project, denoted as "P", belongs to the first layer. It is divided into its WPs. WP "P12" is outsourced to Subcontractor Z. Since for this subcontractor it is a project by itself, it is denoted as project Z. For its proper execution, the subcontractor generates its WBS, as denoted by the Z work packages. The WBS which is generated for project Z, is the second layer within the WBSs set of layers. The same routine of generating more layers will be expended as needed. That is, WP "Z11" can be assigned by contractor Z to another subcontractor, who will develop another WBS layer, and so on. Within each of the WBS layer, the project manager responsible for that WBS within its layer, will define WPs according to the rules similar to the ones listed in this study

A problem faced by the owner of the master project "P" is to develop a managerial control system that will enable a proper control of all the layers, an issue which is out of the scope of this paper

3. Conclusion

Analysis of the 219 work packages belonging to the set of projects reviewed under this study revealed that more than 50% of them were of design nature. This high ratio of design WPs

stems from the fact that the study was undertaken in an organization which is highly oriented towards new product development.

Six rules, identified by this study, were used by the study participants to determine the sizes of 93% of the WPs. Since the six rules cover a high portion of the total sample, this group may be considered as a good set to be used for future guidelines of new product development project. By how much this set of rules is relevant to other projects, should be explored by further research.

Out of the six suggested criteria for stopping decomposition of WPs, the most heavily used by far is "Organizational unit responsibility". That is, to stop decomposing a WP as soon as it can be assigned to a specific organizational unit. Adoption of this rule from the PM point of view is very logical, since it enables a clear assignment of responsibility. The organizational unit to which the WP was assigned may further subdivide it into lower level WBS in order to enable further division of responsibility within itself.

As was specified, the conclusion of this research is most relevant to research and development project environment. Further research needs to be done in this important area in order to get better results and definitive conclusions.

authors

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APPENDIX A
SURVEY

WBS and Work Packages Characteristics

Dear Project Manager,

Proper project design is a major consideration that can affect projects' success, of which designing the Work Breakdown Structure (WBS) and its work packages are of utmost importance. Our research, of which this survey is part of, is aimed at studying the factors affecting the decisions concerning a work package configuration. You are kindly requested to fill up this questionnaire. Please make sure to relate to a successful project you've recently managed. Your answers will remain anonymous, and individual's results and will remain confidential. We will be happy to present you with the final results. If you wish so, please add you e-mail address to your completed survey.

Survey: Work Packages Characteristics

In general, the content of a project is decomposed to a level in which breaking down the work further is no longer efficient. At this level the work unit is defined as a work package. You are kindly requested to address the original planning of a successful project, which has/had at least 4 work packages. Complete the required details of each package, of which the reasons that have stopped you from further breaking down the work content, is one of them. You may choose reasons from the list below, or add others.

Below you may find common reasons that may affect the size and choice of a work package:
1. Organizational unit responsibility: The work content decomposition has stopped since it fits an organizational unit.
2. Organizational guidelines: Each work package is created based on fixed organizational guidelines. Please detail those guidelines.
3. Cost estimation: The present size of the work package is at a level where it can be priced easily.
4. Schedule estimation: The present size of the work package is at a level which allows reliable estimation of its duration.
5. Deliverable basis: The work package has a clear deliverable that can be transferred to a customer.
6. Scope of work estimation: The work package fits the description of a specific scope requirement, as defined by the customer (e.g., in the contract).
7. Risk management: The work package fits the resolution needed for risk management
8. Others – please specify.

Please mark and fill in the following:

A. Classification of the project:
- ☐ Development
- ☐ Production
- ☐ Construction
- ☐ Refurbishment
- ☐ Other – please specify: _____

B. Area and classification of the technology:
- ☐ IT
- ☐ Construction
- ☐ Mechanics
- ☐ Electronics
- ☐ Software
- ☐ Hardware
- ☐ Multidisciplinary
- ☐ Other – please specify: _____

C. Years of experience in the area stated above as a PM:
- ☐ 0-5 years
- ☐ 5-10 years
- ☐ 10-15 years
- ☐ 15-20 years
- ☐ 20+ years

D. Total years of experience as a PM:
- ☐ 0-5 years
- ☐ 5-10 years
- ☐ 10-15 years
- ☐ 15-20 years
- ☐ 20+ years

E. Planned cost of the project (in USD): _____

F. Planned calendar duration of the project (in weeks): _____

G. Please select at least 4 and up to 10 work packages, taken from the original project planning of a recently managed project and describe its characteristics specified by the table below:

Work package description:	Type of work package (Design, execution, production, procurement, etc...):	Approximate planned cost (USD):	Approximate planned duration (weeks):	Reasons that've stopped you from decomposing it further (you may use reasons from the list above):	Comments: