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# DEVELOPMENT OF COMPUTATIONAL TOOL FOR THE PROJECT OF CABINS OF AGRICULTURE MACHINERY

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***Abstract.*** *This paper aims to show the development of an application software which includes the phases of planning, project informational and conceptual geared to assist in the establish concepts and the dimension of the cabins for agricultural machinery and its components. In this tool you can perform the storage, integration, query about technical standards information and related literature. The archiving of data is accomplished by using the server (MySQL), which enables you to create an interface over the Integrated Development Environment (IDE) Delphi manipulating the records and inserting operations which automate the registration process. As fas as the data stored is concerned, these refer to two groups, one dedicated to queries, such as images of booths, technical agricultural machinery data available and symbols, and other dedicated to provide the information of the projects developed. After finishing the project registration it will be possible generate reports of the entire process. So, the structure's improvement of the data allows obtaining greater agility in the project of machines cabins and greater reliability of the information processed in the operation station development.*

***Keywords:*** *operation station, product project, database, programming*

## 1. INTRODUCTION

Facing the enterprises and industries' need of research and develop products in a timely manner, which are increasingly limited to fulfill the demand and market competition as well the adoption of systematic methods for the project process, it is important to create tools that are helpful on contribute to solving this problematic. Piacentini et al. (2012) argue that mechanization in agriculture has been demanding new investments such as softwares application in operational control of agricultural machinery. Besides these, Garcia et al. (2003) using the computer program LabView 6i version, developed a software for automatic data acquisition to be used in the evaluation of agricultural machines.

Alonço (2004), in order to systematize the project process for the conception of safes agricultural machines, developed software for storage and search data called Database About Safety Aspects in Agricultural Machines - BDASMA based on NeoBook - PROFESSIONAL MULTIMEDIA. Merchant et al. (2010) choosing the programming language Borland Delphi 3.0 to develop a program that serves to plan mechanization with lower cost per area. As far as the scenario presented by the authors cited above are concerned, it is clear that the software development which aims optimize the production process, management, reduce costs, classifying equipment and agricultural machinery parts are according with the technical development of the sector. In this direction, this work presents the "Software of Aid in Project cabins of agricultural machines - SAPROC", projected to support the project in the planning stages, informational and conceptual project (Baumhardt, 2013).

## 2. SOFTWARE TO AID IN PROJECT OF CABINS OF AGRICULTURAL MACHINES

For the software Aid in Project of Cabins of Agricultural Machines – SAPROC development, first, an analysis of the types of necessary treatments for information to be processed was made, in order to contemplate the phases desired for the project. Later, a search for software programming with the capability to execute them was carried out. The

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"executable" program was developed using the programming language "Borland Delphi Pascal" employing the associated events, allowing the automation of a series of processes contemplating calculations, inserting a data advanced search, inter alia.

On the next step, a study was performed to develop the morphological structure of the tool, in which the links between information, data types and form of storage are defined. Regarding the analyzed phases in the project, it was decided that the "Menu Planning" phase is composed of eleven tabs, which are menus that allow you to access the information for cataloging and/or search data in the program, being nine of them directly related to planning activities, one for selecting the same and the another, to visualize the phase change "landmark" of planning to informational project.

The "Informational Project" menu is intended to define the technical specifications of the project and the security restrictions related to the scope for development, comprising fourteen tabs. According to Back et al. (2008), the project is informational understanding and description of the functional problem, quantitatively and qualitatively, providing the basis for the evaluation criteria and decision-making. Already menu "Conceptual Project" covers the development of physical solutions to know the needs of customers /project's users and consists in eleven tabs that aim to guide the user, from the identification of the functions on the station operating to the concept discription selected to meet the project problem.

Initially, in intent a form of identification and security, the software provides the interface where input is prompted for a name and password for the user logged in the database. The opening screen is composed of drop-down menus "File", "Reports", "Query Database", "About", "Help", "User" and "Exit", which functions are described on Table 1.

Table 1. Functional description of the drop-down menus.

| Drop-down menus | Functions contemplated |
|---|---|
| "File" | Contains, besides the three options set on the main screen, the verification alternative "Project Status", which opens a new window showing the code, description and progress of the project "finished" or "unfinished", as well as the option to ***backup*** of the database. |
| "Reports" | Allows the creation of three types of report, general project information "General", presentation of the link between a particular project requirement with another, "relations R. P. " and print a document from the planning stage "Planning". |
| "Query Database" | Bring as options to query the database "Patents", "Agricultural machines available in the market" and "Symbols". |
| "About" | Brings brief description of the software' propositions. |
| "Help" | Offers information for contact in case of questions. |
| "User" | Seek the registration of the software's users, informing the permission of themselves relative to local access, view and/or edit information. |
| "Exit" | Brings the output mode of the program. |

The menu available also three more options, "New Project", "Project Edit View" and "Query Edit Influential factors in Project" (Fig. 1), which like the parts that compose them, are presented separately.


Figure 1. Interface SAPROC to initial screen

The "New Project" menu is intended for a new registration, on which occurs in the assignment of a code, with subsequent redirection to a zone that presents the three principal top tabs, the phases available to the project process:

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Planning, Informational Project and Conceptual Project. However, the option "Edit View/Project" brings a window asking you to select the project option that you want to perform the edit and or insertion of data. Still on the home screen via the button "View/Edit Influential factors in Project", the user is taken directly to the factors of influence on the project area, to be viewed and/or edited.

### 2.1 Planning Phase

The planning stage starts with the selection of documents to be prepared in the project plan that can be "Project Charter", "Parties Involved", "Communications Plan", "Scope Statement", "Decomposition Structure" "Project Risk", "List of Activities and Completion Schedule", "List Physical Resources / Project Costs" and "Records of Lessons Learned". The Table 2 presents a brief description of such activities.

Table 2. Planning Phase's documents with brief conceptualization.

| Document name | Description |
|---|---|
| Project Chart | Exposes the project goals and the product to be developed. |
| Involved Parts | Encompasses the identification of direct and indirect customers, such as members of the development team |
| Communications Plan | Presents the information that will be formally notified, the frequency and broadcast media to be used. |
| Scope Statement | Brings the project justification and its restrictions, as well the characteristics of the product. |
| Decomposition Structure | Covers the Analitic Structure of the Project- ESP, is the subdivision of the main results in smaller components until they reach the level of the activities' details. |
| Project Risk | Approaches the risks inherent to the project. |
| Activities and Completion Schedule list | Presents the activities to be developed correlated with the period for execution. |
| Physical Resources / Project Costs list | Include a description of the materials and supplies necessary for the project development, such as equipment, norms, etc., as well their costs. |
| Records of Lessons Learned | Brings considerations of the development team regarding the experiences throughout the project. |

After selection, the software creates a text file, following the models available in the "planning model" folder, for each activity, which allows the inclusion of charts, timelines, images, tables, inter alias, to make the way storage easier, considering the specifics of each project. The program develops a new folder to store these files using the nomenclature given to the project running.

It is highlighted that the selection of activities was based on the Reference Model for Process Development of Agricultural Machinery (Romano, 2003), emphasizing the bond created between the list of activities and execution schedule, as well as the list of resources with physical project costs.

### 2.2 Informational Project

The informational phase of the project begins with the tab "Factors of Influence" (Fig. 2), which presents the characteristics to be observed regarding the various aspects present in the operating cab, as "symbols", "Controls", "dials "," seat "," access "," structure "," Interior Space "," Field of Vision "," Emergency Exit "," Security - Overview "and" Environment ", the latter being subdivided into" Vibration "," Noise "," illumination "," Suspended particles "and" Weather ".

On each of these menus is available a text file (*. doc or *. docx) for the relatated information integration, however, unlike those in the planning stage, theses single files are only for consultation in any cab project and/or components being stored in the folder "files norms." It was also included for each influencing factor, a description table of requirements of related projects, herewith with an unit measure and reference parameters that are stored in the "SQL" database.

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Figure 2. Interface SAPROC to the tab "Factors Influence"

A feature found on the "Influential factor" tab is the query to the "Symbols", "Agricultural Machines Available in the Market", "Images Cabins", "Patents" and "Influential factors X standards." The structuring of the bank of symbols was based on "BASIM - Database of Graphic Symbols for Agricultural Machinery", developed by Balestra (2008). Initially, the symbols' database comprises a total of three hundred forty-one icons (Fig. 3a), from the ISO 3767-1 (1998), ISO 3767-1 (2008) and ISO 3767-2 (2008), addressing an amount of functions, from the direction indication of the machine's travel until symbols dedicated to operator's ergonomy.

As for agricultural machines, were implemented technical information of self-propelled sprayers (Fig. 3b). Such data, from approximately forty models, are taken from the project "Determination of the coefficient of technological self-propelled sprayers," in progress at the Laboratory for Research and Development of Agricultural Machines - LASERG of Universidade Federal de Santa Maria - UFSM.

As far as the pictures of cabins (Fig. 3c) are concerned, they came from exhibition records of agriculture fairs in the period 2007 to 2011. This database has included more than seventy images, with approximately twenty models of self-propelled sprayers from eleven manufacturers.


a b c

Figure 3. Interface SAPROC for searching graphic symbols (a), technical data of self-propelled sprayers (b) and cabins of agricultural machines (c)

Considering that most of the norms related to the project of cabins have features relevant to more than a factor of influence, the "Factors Influence X Norms" presents a diagram with such links. This scheme also shows information such as traceability, status and category of the factor of influence in which the norm is stored.

Once the influential factors in the project were checked, the following tabs "Customer Needs" and "Customer Requirements" refer respectively to information on customer needs, usually identified through questionnaires and interviews semi-structured, and the reformulation of such expressions using the verbs be or have, in order to present a language more suited to the engineering.

The tab "Hierarchization of Customer Requirements" aims to identify the most important user requirements for the project, using the tool "Mudge diagram" (Fig. 4). Soon as the judgments have finished, the software does the calculation of the importance percentages, allowing their hierarchization.

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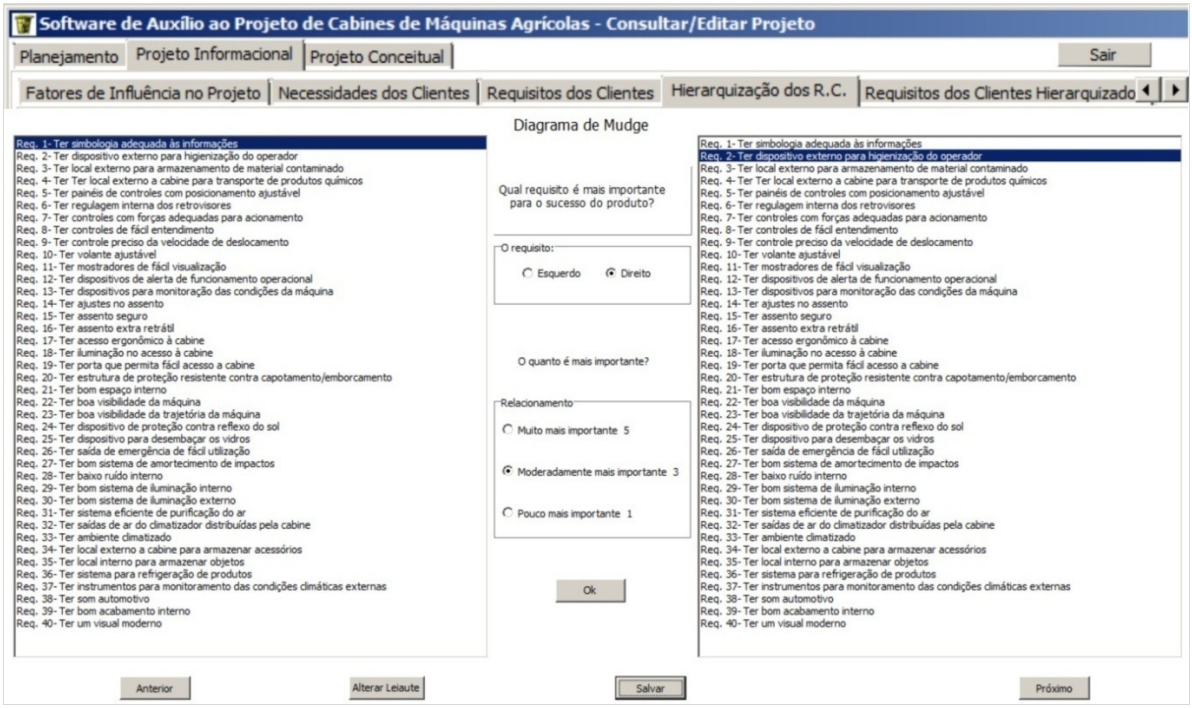


Figure 4. Interface SAPROC to the tab "Hierarquization of the customer requirements - R.C."

On the interface "Hierarquization requirements of the customer" the presentation is performed in sequential order, the customer requirements that should be prioritized throughout the project process, as well as their identification numbers "N° RC" and their respective percentages "Rankings".

Sequentially, the "Selection RP" provides the user an influential factors selection to be considered during the project in development. Once a particular category was enable, the program seeks the information in the database "SQL" of all the project requirements related fields, and insert in the next tab, "Project Requirements." On this one, have a spreadsheet that being half-filled with the information requirements of the project, unit of measure and its influential factor selected on the previous tab, the user must perform a scan of the requirement in question, seeking his bond with the more relevant customer requirement. Another procedure to be made is the attribution of the "Signal Qualifier" that can be "+" when the increase of the characteristic is preferable, "-" to reduce and "XX" in situations which you want changes do not occur in the target value to be defined in the project specifications. The program also allows, by the button "Add project Requirements," the inclusion of other requirements that were not contemplated in the factors of influence.

In the "Hierarchization of project Requirements - RP 01/02", is made the filling of the roof of house of quality matrix. To do that, it uses a spreadsheet similar to that used on the tool "Diagram Mudge", aiming to check the degree of commitment among project requirements. It is emphasized that positive links refer to simultaneous improvement trends for both requirements, either by increasing or decreasing a certain characteristic. As for the negative occur when the reverse occurs, for example: a factor increasing (project requirement) causes a reduction of another.

On "Consultation relations of project Requirements - PR", the user can verify the existing link between the selected project requirement and the others judgments made on the previous tab, as well as the visualization this link's scale.

The tab "Hierarchization of project Requirements - RP 02/02" is for the project requirements prioritization by using the center part of the house of quality matrix, which is related to customers' requirements with the engineering characteristics (project requirements), this link purpose is to obtain indicative (values) about how much each user needs or desires affect or is affected by a specific project requirement (Back et al., 2008).

At the end of links, the software performs the calculation based on the Eq (1) (Back et al., 2008), which add up to each requirement of the project, the results of multiplying the "weight" assigned to the requirement user (from the diagram Mudge) by the value of the link between the user requirement and project attributed this activity.

$$RP_j = \sum_{i}^{n} pru_{\underline{i}} + v_{ij} (i = 1 \quad a \quad n \quad e \quad j = 1 \; a \; m) \tag{1}$$

in which,

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$RP_j$ - importance value of the project requirement j;
$pru_i$ - weight percentage importance of the requirement of user i;
$v_{ij}$ - value of the link between the project requirement j and user requirement i; and
m - total number of project requirements.

This procedure allows the hierarchyzation of project requirements, aiming prioritize the characteristics considered most promising for the success of the product. These results are illustrated in the next tab "Requirements Projects hierarchized" through a spreadsheet, with the ranking, the value obtained in the house of quality, the identification number of the initial project requirement "N°. RP" as well as your description, unit of measure and the direction desired.

In "Project Specifications", the information requirements of the project hierarchized, their respective units of measures and benchmarks are available automatically, leaving the user filling in the desired target value, how to assess it and the aspects to be sent when this value is not implemented for the requirement of the project in question. These data complement the technical specifications of the project, which is the end result of user needs transformation process, often cited as the most important part of product development (Back et al., 2008).

The tab "Selecting Security Restrictions" presents a spreadsheet with information relating to security constraints, stored on influential factor "Security - General Aspects", allowing the user to select the pertinent influential factors to the project being developed. These has been represented in the last tab of the project informational "Security Restrictions" in order to facilitate viewing and checking of items covered, in other words, the obligatory observance of the project.

### 2.3 Conceptual Project

The first tab of this phase is the "Global Function", is for filling the information dealing with the function "bigger" of the technical system, in other words, the user must identify and prepare, preferably employing a verb and a noun, a function description that includes all other presents, as well as the link of the inputs and outputs of energy, material and signal involved. On "Partial Function" is the unfolding global function in roles that have a lower complexity rate, called "partial", usually regarding to the subsystems involved in the project, which receive a code for traceability.

Later, under "Elementary Function" tab the user must perform a new subdivision, for each partial function enumerate in the previous step, searching the record of elementary functions of the technical system, which represent the last level of deployment and must have at least one solution principle of Physical able to answer it. Similar to that developed for the global function, the software makes available fields for the record amounts of energy involved, material and signal to the input and output of the respective elementary function.

On the tab projected for developing of structures functions "Elaborate Structure of Functions", the user must present possible configurations of links between elementary functions and / or modules, so that they can be evaluated in the following steps, pointing out the most promising for project. Such structures can be formed by selecting elementary functions to elaborate the problem's solution, modules development, which occurs in the grouping of functions and in rearrangement between functional links, which can be in series and / or parallel. Later on the "Structures Functions" tab, the user can view each structure developed in the previous step, as well as the functions and / or modules that compose it and their traceability codes.

In the "Frame Selection Function" it is performed a selection of the most suitable structure for judged as a successful product. For this procedure, the software makes use the tool Matrix Selection Functional Structures, developed by Maribondo (2000), which is considered the requirements of the customers hierarchized and their respective weights obtained in the Diagram Mudge, these results from the phase Informational Project. After the judgment of the structures, the software calculates reporting the scores and order "position", considering the best structure for the project. Such information can be visualized on the next tab "Structure Function Selected".

The tab "Principles of Solution" (Fig. 5) has a tool-based interface "Morphological matrix", bringing different solution principles for each elementary function and / or module, allowing different combinations of elements or parameters in order to find a new solution to the problem (Back et al. 2008). At the end of this matrix, it is given an automated manner to the first and second column, which the codes and descriptions of the functions or modules respectively are shown.

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Figure 5. Interface SAPROC for tabs "Principles of Solution"

The user must enter at least one representative scheme of solution principle, BMP format picture to each function or module. Later, it is possible to make up five variants for the conception of the product under development, using different solution principles. It emphasizes the importance of checking the compatibility between them at the time of this selection, so that it is possible its final configuration.

On "Visualization of variants" are presented for viewing and conference, the solution principles selected according to variants developed in the project. At the bottom, the user must fetch the files with the final images of these variants concepts.

On the tab "Concept Selection" (Fig. 6), by using the tool "Decision Matrix", the user judges the most promising concept for the product development. On such matrix, the first column is dedicated to some of the information of the technical specifications of the project presentation, more precisely, the code, the project requirement, the unit of measurement, the value assigned to the target requirement and the weight from house of quality matrix.


Figure 6. Interface SAPROC for " Concept Selection"

Facing this information, applying the criteria shown in Table 3, the user indicates how the variant being assessed attends the requirement of the project in question, considering the above information, for example, the value assigned to

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the meta requirement. Then the software performs the multiplication of the weight assigned to the variant in attendance specification, the values from the array home quality. Finally, for each variant is realized the sum of these values, reporting the score and the ratings obtained on the other evaluated.

Table 3. Parameters for evaluation of variants of the project conception.

| Parameters of evaluation | How the variant attends the specification |
|---|---|
| Vi = 0 | Not attends |
| Vi = 3 | Attends weakly |
| Vi = 5 | Attends moderately |
| Vi = 7 | Attends well |
| Vi = 10 | Attends very well |

To finalize, the conceptual project phase has the tab "Description of Concept", which before the specifics of each project in relation to the information presentation "text and images", the program employs a file text editor to storage of these data. At the end of this activity, the user is redirected to the home screen of the software, in which by the drop-down menus, as detailed earlier in this paper, it is possible to create project reports in accordance with the desired information.

## 3. CONCLUSIONS

Facing the limited use of the ergonomics knowledges and safety in projects of cabins of agricultural machines, largerly due to the absence of a proper structuring of the factors involved, the large volume of information available in publications and norms, herewith the time constraints acceptable, considering the economic and competitive for the project activity, it is considered that the development and use of the tool "SAPROC" proved to be: a way suitable for the query / edition of the factors and parameters involved, as well as the orientation to the projecter, regarding the proposed sequence and aid in the transformation of information using the links and calculations performed for the activities throughout the development of the project, a contribution to the incorporation of technical standards information and related literature, presenting a visual interface that facilitates understanding of the main issues involved on the project cabins, and reduce or eliminate the loss of information throughout the project, liable to occur when you have many factors to consider, and an instrument that promotes greater flexibility in inserting, updating, and search of project data and formalization of these, through the documents produced.

## 4. REFERENCES

Alonço, A. dos S. Banco de dados sobre aspectos de segurança em máquinas agrícolas - BDASMA. ***Software,*** Universidade Federal de Santa Catarina, 2004.

Back, N.; Ogliari, A.; Dias, A.; Silva, J. C. da. ***Projeto integrado de produtos***: planejamento, concepção e modelagem. Barueri: Manole, 2008. 601 p.

Balestra, M. R. G. Levantamento e identificação de símbolos gráficos utilizados para caracterizar comandos e controles de tratores agrícolas. 2008. 81 f. ***Dissertação*** (Mestrado em Engenharia Agrícola) - Universidade Federal De Santa Maria, Santa Maria, 2008.

Baumhardt, U. B. Metodologia para concepção de cabines de máquinas agrícolas com enfoque na segurança e ergonomia. 2013. 258 f. ***Tese*** (Doutorado em Engenharia Agrícola) – Universidade Federal de Santa Maria, Santa Maria, 2013.

Garcia, R. F.; Queiroz, D. M. de; Miyagaki, O. H.; Pinto, F. de A de C. Programa computacional para aquisição de dados para avaliação de máquinas agrícolas. ***Revista Brasileira de Engenharia Agrícola e Ambiental***, Campina Grande, v. 7, n. 2, p. 375-81, 2003.

ISO. International Organization for Standardization. ISO 3767-1: ***Tractors, machinery for agriculture and forestry, powered lawn and garden equipment*** - Symbols for operator controls and other displays - Part 1: Common symbols. 1998.

ISO. International Organization for Standardization. ISO 3767-1: ***Tractors, machinery for agriculture and forestry, powered lawn and garden equipment*** – Symbols for operator controls and other displays – Part 1: Common symbols. Amendment 1: Additional symbols. 2008.

ISO. International Organization for Standardization. ISO 3767-2: ***Tractors machinery for agriculture an forestry, powered lawn and garden equipment*** – Symbols for operator controls and other displays – Part 2: Symbols for agricultural tractors an machinery. 2008.

ISSN 2176-5480



Maribondo, J. de F. Desenvolvimento de uma metodologia de projeto de sistemas modulares, aplicada a unidades de processamento de resíduos sólidos domiciliares. 2000. 277 f. *Tese* (Doutorado em Engenharia Mecânica) – Universidade Federal de Santa Catarina, Florianópolis, 2000.

Mercante, E.; Souza, E. G. de; Johann, J. A.; Filho, A. G.; Uribe-opazo, M. A. Software para planejamento racional de máquinas agrícolas. *Engenharia Agrícola*, Jaboticabal, v. 30, n. 2, p. 322-3, mar/abr. 2010.

Piacentini, L.; Souza, E. G de; Uribe-opazo, M. A.; Nóbrega, L. H. P.; Milan, M. Software para estimativa do custo operacional de máquinas agrícolas – MAQCONTROL. *Engenharia Agrícola*, Jaboticabal, v. 32, n. 3, p. 609-23, maio/jun. 2012.

## 5. RESPONSIBILITY NOTICE

We, BAUMHARDT, Ulisses Benedetti; ALONÇO, Airton dos Santos; FERREIRA, Cristiano Corrêa; ALVES, Rafael Martins; ALVES, Rodrigo Martins; ZONNER, Alex Rovian; MENDES, Douglas Ramos; took the responsibility for the content and authenticity of the work entitled “DEVELOPMENT OF COMPUTATIONAL TOOL FOR THE PROJECT OF CABINS OF AGRICULTURE MACHINERY”.