

Preliminary Requirements for an Ergonomics Problem Reporting System

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Abstract— Oil refineries are inherently dangerous work environments. Petrobras, a Brazilian company, is at the forefront of improving safety in the production of crude oil and oil products. The company has implemented an ergonomic problem reporting system to identify and resolve physical ergonomic problems at their refineries. This paper analyzes the current ergonomic problem reporting system and defines preliminary requirements for an improved system that accommodates all stakeholders and streamlines the process of problem reporting and resolution.

I. INTRODUCTION

Petrobras, a Brazilian government owned petroleum-based company, is an industry leader in health and safety management in the workplace. Their web-based database called Sistema de Informação de SMS do Abastecimento (SISA) focuses on identifying, analyzing, and tracking physical ergonomic problems and their solutions. Currently workers identify problems in the workplace and send an email to SMS (Dept. of Health, Safety, and Environment) management (for this paper, the Petrobras Team). The Petrobras Team is responsible for filtering requests and then registering the identified problems (referred to as demands) in the reporting system. An ergonomics consulting team (for this paper, consultants) then analyzes and suggests solutions to these demands.

While SISA has been successfully used to resolve many physical ergonomics problems at Petrobras, the system has some problems ranging from human-computer interface issues to inefficiencies in the overall process of collecting,

analyzing, and resolving demands. Some of the data items that should be entered into the web-based support tool are ambiguous, leading to overlap and confusion when it comes time to analyze the demands.

Successful reporting systems have several key characteristics. Reporting systems must provide both appropriate functionality and usability [1], inform workers and management about what types of incidents to report [2], and provide management with useful feedback [3]. Industry requires reporting forms that utilize relational databases in order to organize and track the high volume of quantitative data created [4]. Databases lend themselves to statistical and trend analyses which in turn aid decision makers.

This paper analyzes the SISA problem reporting system for ergonomics problems and presents requirements to improve the software support tool and associated processes.

II. METHODS

The methodological approach consisted of understanding the current system (including processes and software tools), identifying problems with the current system, and developing requirements for an improved system.

A. Understanding the Current System

The analyst team observed the process from problem solicitation to resolution. The analysts interacted with the SISA web-based support tool, interviewed users, observed the consultants, and reviewed quarterly reports written by the consultants who analyze the reported problems.

The interviewees included members of the Petrobras Team and consultants from Reduc (one of the Brazilian refineries) and other refineries, as well as SISA software developers. Seven phone interviews were conducted with the Petrobras Team and consultants at different refineries to discuss the information fields included in the SISA web-based interface. The analysts conducted in person interviews with the Petrobras Team at Reduc and at Petrobras headquarters with the management responsible for the ergonomics program at all of the industrial plants. The purpose of these meetings was to present questions regarding the SISA system that had arisen during field work.

In a refinery, the industrial area is defined as the physical location where the chemical processes occur. The analysts accompanied the consultant team in one industrial area and observed problem information collection. The analysts observed the consultant team during the course of a typical visit with a worker who had reported a physical ergonomics

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problem. The consultants met with the worker and discussed the reported issue. The worker then led the consultants to the location of the ergonomics problem. The consultants made an ergonomics assessment which included taking pictures and asking clarifying questions.

The analysts reviewed the consultant team's quarterly reports to the Petrobras Team. Every three to four months, the consulting team presents the Petrobras Team with a report about all the ergonomics problems that were solved during the previous three to four months. These reports include pictures, classifications of typical problems, and classifications of typical solutions.

B. Problem Identification

After the analysts gained familiarity with the current system, they targeted problems in three separate ways. There were several problems uncovered directly through interviews with the Petrobras Team, consultants, and the developers of the web-based software tool. In these cases, the interviewee would specifically identify a problem with the current system. For example, one such interview led to a requirement in which SISA must run in both a resolution of 1024 by 768 pixels as well as in 800 by 600 pixels (currently the web-based tool only works well with a resolution of 1024 by 768 pixels). Other problems were identified through the analysts' direct interaction with the web-based tool. However, the majority of problems were uncovered by the analysts applying their knowledge of human factors engineering combined with literature reviews of other successful reporting systems within the industry.

C. Requirements

The analysts developed a set of requirements by evaluating improvements made in three major categories: tool functionality, process, and training. The analysts looked at making improvements with the overall process of soliciting, registering, analyzing and solving ergonomics problems. They addressed lack of knowledge issues in two areas: 1) a lack of understanding of what ergonomics is, and 2) lack of knowledge of how to use the SISA tool. Finally, requirements for the SISA tool itself were derived.

III. RESULTS

Results are divided into three categories: understanding the current system, problems with the current system, and requirements for an improved system.

A. Understanding the Current System

The analysts had to understand the current system. However, there was no user documentation for the web-based tool or a set of procedures for employees to follow. Therefore, the analysts conducted interviews and developed process maps of the system based on these interviews as well as interaction with the web-based tool. This effort resulted in a system process flow chart and a description of the current process.

Figure 1 summarizes the system process flow. The numbered boxes, described below, are steps supported by the current implementation of the SISA tool. Other steps are currently handed via manual processes or by other tools (such as email).

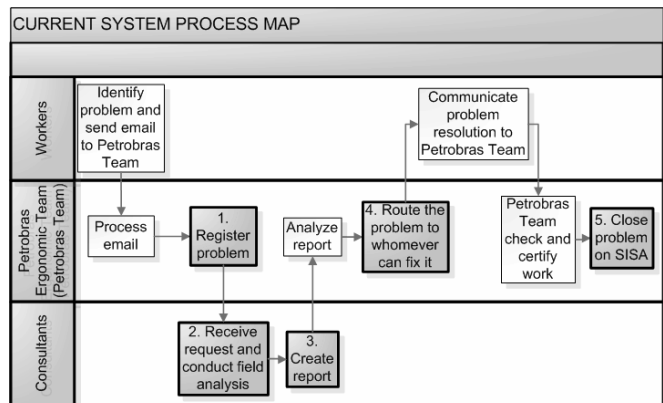


Fig 1. Current System Process Map

1) Process Email/Problem Registration:

The Petrobras Team determines whether the request is an actual ergonomic problem. These problems are then registered in the SISA web-based tool by the Petrobras Team.

2) Receive request and conduct field analysis:

A team of ergonomics consultants receives registered SISA problems. They conduct ergonomics assessments by going to the field, meeting with the employee that reported the problem, collecting data, taking pictures, and verifying the existence of the problem.

3) Create report:

The consultant team analyzes the problem and fills out the analysis forms in the SISA tool. This analysis includes a recommendation of how to fix the problem in addition to the cost estimates to implement the proposed solution.

4) Route problem:

The Petrobras Team then uses the report to determine whether or not to implement the solution. If they fix the problem, the solution gets routed to whomever can fix it (for example, construction team if the problem is building a new staircase).

5) Close problem report on SISA:

After the problem has been resolved, the Petrobras Team closes the problem report via the SISA tool.

B. Identified Problems

The analysts identified both process and SISA software problems (Figure 2). The problems were defined by a description of the problem as well as type of problem.

Problem	Description	Category
Clarity of interface	The registering and analyzing demands screens look similar. It is difficult to tell immediately where you are in the system and it may lead to mistakes because both screens may have the same named fields. As an example the field 'description' is present in both screens. In addition, in each of the screens, both "view" and "edit" modes are almost identical which again may be confusing.	Interface
Overlap in Fields	Options for users overlap and may confuse them. Some fields request very similar information and most of the users are confused by the apparent overlap. The analysts encountered some examples where users simply copy the information they provide in one field into another.	Interface
Interface does not work in 800 X 600	The system was built into a 1024 x 768 screen resolution. Some users complain about it because of the difficulty in seeing the small icons and letters. Also, some computer monitors don't support the high screen resolution.	Interface
Lack of Clarity in fields	Users reported difficulty understanding what each field means and requires. They also described a lack of documentation both in the system, like a help menu, or in a handbook or users manual. 9 of 12 registering demand fields and 11 of 20 analysis demand fields were cited as difficult to understand by at least one of the 12 users interviewed.	Interface
No Management interface exists	There is no way for the Petrobras Team to see a single interface that has all the information they need to support their work, for example, total number of demands divided by demand status, total time elapsed during each demand status, performance indicators divided by the 12 different refineries, and others.	Interface/ Functionality
Clustering demands	Although the system requires users to enter some information for categorization, this information does not seem to be used for making the system more efficient. For example, some demands might be related to the exact same problem but in a different refinery or even in a different place in the same refinery and the system would not be able to relate them and take advantage of that.	Interface/ Functionality
Searching prioritizing demands	It is somewhat the same as the "Clustering demands" problem. The system has a prioritizing demands indicator called GxUxT but there is not a way to search demands based on that. It means that this tool is not providing as much functionality as possible.	Interface/ Functionality
No tracking solutions module exists	There is no way for anyone to know what happens with the demands after they have been analyzed. The system lacks a module to check if the suggested solutions were implemented accordingly, how long it took to implement solutions, how much it cost, and others.	Interface/ Functionality
Time frame field within analyzing demands	The system has approximately 254 demands registered on it, but the Petrobras Team can not determine how many are simplistic (i.e. I need a new chair) and how many are long-term projects. It does not allow the Petrobras Team to correctly estimate the total effort required to fix them all.	Interface/ Functionality
Incongruent processes across refineries	The current process flowcharts are different at each of the refineries. In some of the refineries the Petrobras Team is registering the new demands into the system and at the same time, in other refineries, the consultants do it.	Process
System does not support dynamic use	The system is not always ready for receiving new demand registrations. The system was not developed for different users to work on different parts of the process at the same time. Different interfaces with the ability to provide the necessary functionality for each type of user is needed.	Process/ System
Lack of Uniformity in Reporting	When entering information users are inconsistent. The same field can be filled out in many ways at different refineries and even within refineries.	Training
Employees don't understand Ergonomics Problems	Workers have trouble identifying ergonomics problems and differentiating them from other types of problems. On the other hand, some SISA users lack knowledge in ergonomics and it makes filling out forms in the system an even more difficult task.	Training

Fig. 2. List of Problems

The problems were categorized into five different types: Interface, Functionality, Training, Process, System (or any combination of the five). An interface problem was defined as a problem involved with the appearance or clarity of information in the actual SISA tool itself. Functionality referred to the missing or incomplete functionality in the SISA tool. Several problems were categorized as a combination of Interface/Functionality. For example, lack of categorization of problems is both an interface problem because there is no field within the form for reporting the category of problem as well as a functionality problem because there is no way for the user to then categorize these problems. Training related problems stemmed from a lack of understanding, not knowing if a problem is an ergonomic problem, the SISA tool, or both. Workers are sometimes confused about problem classification, workers may think that a simple problem; such as litter, is an ergonomic problem when in actuality it is not. Process related problems

came from inconsistent processes across refineries or with general inefficiencies in the way a problem went from solicitation (first phase) to resolution (last phase). System related problems referred to deficiencies in the implementation of the system.

C. Requirements

This section includes the requirements the analysts developed for an improved system and process. Figure 3 summarizes the improved process flow. In Figure 3, the blocks with white background are actions that are a part of the process related to the SISA system but do not represent a step supported by the SISA software. The blocks with gray background represent steps to be supported by the SISA system and requirements for each of them are specified below.

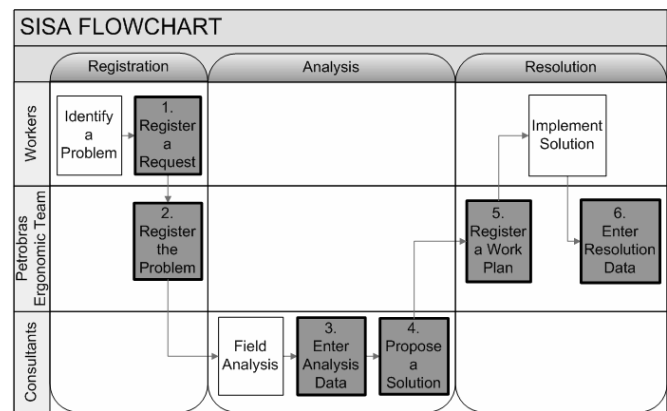


Fig. 3. New Process Flow Chart

In the top of the flowchart, there are three main categories which are registration, analysis and resolution. Those represent the three major functions of the SISA system and helps in defining which user groups should work with each of them. The system should support three sets of users: the workers who identify problems, the consultants who analyze the problems and propose solutions, and the Petrobras Team (Management) who determines if/how the problems are solved.

For each step to be supported by the new SISA software the analysts developed an operational concept and a set of requirements.

1. Register a Request

Operational Concept:

Workers identify ergonomic problems in the field and register a request for analysis into the SISA system using a web-based form with a predefined format. The registration includes information such as the location and type of ergonomic problem that was identified, how this problem affects their daily work, and other information. The web-based request form will help keep track of all requests made by workers and at the same time will eliminate the Petrobras Team typing basic information in the registration step. SISA will identify workers filling requests by their PIN numbers (a

unique employee number). Later on, the system can send notifications to the workers as their request progresses through the system.

Requirements:

- The system shall allow workers to register a problem report in a web-based form.
- The system shall record the worker who registered the problem by his PIN number and send automatic status updates as the problem is analyzed.
- The system shall allow workers to submit problem reports at any time.
- The system shall be able to record the new problem report as a 'pending registration' status.

2. Register the Problem

Operational Concept:

The Petrobras Team members will receive all the problem reports from the workers and will decide which of them should be registered in the SISA system and which should not. If they decide the request is valid, they will register the request as a valid problem. If they decide the request is not valid, they will document why. This will generate an email back to the worker who registered the problem to indicate why it is not valid, and close the report. If it is a valid problem the system will notify the worker who reported the problem that it has been registered as such and require the Petrobras Team to input more detailed information about the request. This information will include the SMS policy that relates to the problem, the category of the problem, and an indicator used to prioritize problems: the gravity, tendency and urgency of the problem. All the information provided by the Petrobras Team members will be based on their past knowledge of similar problems as well as their knowledge of ergonomics in general. If more information is needed, the Petrobras Team member can send a message to the worker who requested the problem.

Currently this information is exchanged through emails. However, the improved system would store this exchange (track all messages between the Petrobras Team and the workers who submitted a request for a problem). If a request is denied, the SISA system will request that the Petrobras Team member fill out a brief explanation form to be sent back to the worker. This explanation will contain selections for some of the most common reasons for denying a request and allow for more specific input if needed. This explanation form will generate a message for the worker who requested the problem and route the message to the appropriate worker based on his PIN which the system will have already stored.

Requirements:

- The system shall provide the Petrobras Team with a view of all the pending problem reports to be registered or denied with ability to sort/filter the requests in various ways (worker ID, refinery, date of report, free text search, etc.)

- The system shall provide a link to the form previously filled out by the worker with the request information and let the Petrobras Team members enter more information, such as, the category of the problem, the gravity, tendency, and urgency of the demand analysis, and others in order to complete the problem report registration.
- If the request is denied, the system shall provide an explanation form to be filled with the reason why the request was denied.
- After the explanation form is filled out, the system shall automatically send a message to the worker who requested the analysis telling him/her that it was not accepted and the reasons why.
- If the request is accepted, the system shall provide feedback to the worker telling him/her that his/her problem moves forward in the process.
- The system shall be able to change and record the 'pending registration' status to 'request denied' or 'registered problem status'.

3. Enter Analysis Data

Operational Concept:

Consultants check the SISA system for registered problems. The registered problems will be shown in different classifications. Consultants will decide which problem to analyze (the mechanism for the prioritization is beyond the scope of this work). The system will provide a printable version of the registered information to guide the consultants through the ergonomic assessment. Consultants go to the field and meet with the worker that reported the problem. Consultants verify the existence of an ergonomic problem and document the situation by collecting data, video, and photographs. After returning to their office, the consultants will fill out the analysis form in the SISA system. The form includes information such as a more detailed problem description, environmental conditions, ergonomic methods and tools used during the field visit, and others. This step will generate a status change that indicates that a consultant has started working on the problem.

Requirements:

- The system shall provide the consultants a view with all the registered problems pending analysis in various possible classifications.
- The systems shall enable a printable version of the registered problem to guide consultants through their field work
- The system shall provide a form for consultants to enter information about the field analysis, including the ability to upload pictures.
- The system shall be able to change the 'registered problem' status to 'problem in review' and automatically send a message to the worker telling him that the problem is currently being reviewed by consultants.

4. Propose a Solution

Operational Concept:

After analyzing the problem the consultants open another form in the SISA system in order to include a proposed solution for solving the problem. This form should be linked with the previous step form so that there is not a change in status until the end of this fourth step. It also implies that the consultants should not leave the Enter Analysis Form before entering information on the proposed solution form. The consultants will also provide estimates of cost and time to implement the proposed solution as a metric to help in the decision-making process of the Petrobras Team. After entering the proposed solution form, the SISA system will change problem status and will automatically send a message to the worker who requested the problem telling him that his problem has been analyzed.

Requirements:

- The system shall provide functionality for including a proposed solution.
- The system shall not let the consultants close an analysis data entry before filling out the proposed solution form.
- The system shall be able to change the 'problem in review' status to 'problem analyzed' and automatically send a message to the worker telling him that a proposed solution has been identified.

5. Register a Work Plan

Operational Concept:

The system will provide Petrobras Team members a view with all 'problems analyzed'. The items in this view should have functionality for classification in several different ways, including classification through the priority and cost indicators provided by the consultants in the analysis steps. The Petrobras Team will decide which of the analyzed problems will be scheduled to be resolved and what resources will be allocated for that. This information should be entered in the SISA system by filling another electronic form. It will change the item status to 'pending solution'.

Requirements:

- The system shall provide the Petrobras Team a view with all the analyzed problems and their proposed solutions and be able to sort/filter the view in various ways (e.g., by date, location, cost, urgency, etc.).
- The system shall provide a form for entering a solution schedule and resource allocation plan for solving the problem.
- The system shall be able to change the 'problem analyzed' status to 'pending solution' status and automatically send a message to the worker telling him that his problem report has been analyzed.

6. Enter Conclusion Data

Operational Concept:

After the plans are executed a Petrobras Team member will visit the site to certify that all the solutions were adequately implemented. A final form should be filled out in the SISA system with some final information about the problem solution. This should include information such as conclusion date, and photos from the site. The system will change the item status and e-mail the worker who registered the problem.

Requirements:

- The system shall provide a form to enter information about solutions implemented.
- The system shall be able to change the 'pending solution' status to 'problem solved' status and automatically send a message to the worker telling him that his problem report finished the SISA process.

7. Management Graphical Interface

Operational Concept:

One of the greatest features of the new system should be the ability to show summarized information about the system status at any time with some key performance indicators. This management graphical interface will show the number of problems currently existing in each of the 6 distinct statuses in the 12 different refineries. More detailed information should be accessible in detail views if requested. The management graphical interface will help the Petrobras Team to understand at a glance where the problems are and which refineries need extra attention.

Requirements:

- The system shall provide a management graphical interface showing summarized key performance indicators,
- The management graphical interface should provide more detailed information in different levels upon request.

Figure 4 highlights the set of identified problems from Figure 2 addressed by these requirements. In Figure 4, the white background cells are problems that are corrected by the new requirements, while the dark grey background ones are not corrected. The light grey background ones are partly addressed.

IV. CONCLUSION

This paper delivered an analysis of the current SISA system, a list of problems with the current system, and preliminary requirements for the creation of a better system. The requirements have addressed nine of the fourteen problems identified through field research with the current system.

Problem
Clarity of interface
Overlap in Fields
Interface does not work in 800 X 600
Lack of Clarity in fields
No Management interface exists
Clustering demands
Searching prioritizing demands
No tracking solutions module exists
Time frame field within analyzing demands
Incongruent processes across refineries
System does not support dynamic use
Lack of Uniformity in Reporting
Employees don't understand Ergonomics Problems

Fig. 4. Problems Addressed by New Requirements)

The proposed solution will allow all related problem report information in one database, with appropriate access and status change reports for all stakeholders, with a better ability to track problem reports and requests. The feedback provided to workers should enable better understanding over time of what constitutes an ergonomics problem.

Future work will include writing requirements for the system that address the remaining five problems. Also, a prototype of the improved SISA system will be built and tested.

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