Risks inherent to management in long term industrial automation software solutions

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Abstract

When put into perspective, industrial automation is a relatively new engineering discipline. Particularly in the long pipeline projects, in which industrial automation usually amounts for about four percent of the total budget, it is often neglected proper management for the solutions created and delivered by automation activities. Automation intelligent equipment often demands different configuration files that evolve as the project matures or the operational demands are altered. Additionally, the personnel that work with automation are usually composed of specialists trained for specific equipment configuration.

Thus such knowledge ends up restricted to that small group of people and out of reach of the managerial staff. Nevertheless, the lack of management of automation production leads to risks that are inherent to the activity and often neglected. Furthermore, as the automation implanted for a given project itself develops into a long term managerial problem (maintenance), it leads to more specific risks that go beyond the construction period. It is then reasonable to conclude that the management of automation solutions is critical to guarantee and increase the project lifespan and making it an easier system to maintain.

Throughout this article it is assessed which and how such automation management risks impact on long pipeline engineering projects and regular operations. A risk analysis of the activity was performed in order to determine and classify the risks and develop a possible response plan. Furthermore, a managerial solution, applied in a Brazilian pipeline company is studied through the use of structured and non-structured interviews answered by the system users, managers and developers.

The authors perceived that it is possible to suppress or at least attenuate most of the risks determined by taking simple managerial actions such as a more restrict software versioning control such as it was done in the Brazilian pipeline company case-study. That brings the necessary professionals to a more integrated group that can consciously choose to avoid, mitigate, accept or transfer each risk.

1. Introduction

Engineer teams often tend to assess thoroughly the activities that are most important in terms of budged allocation. In this scenario, industrial automation is often neglected as it usually amounts for about four percent of the total budged for a new engineering project. Among industrial automation activities, one that is particularly neglected is the management of industrial automation configuration files and documents.

Automation intelligent equipment often demands different configuration files that evolve as the project matures or the operational demands are altered. Additionally, the personnel that work with automation are usually composed of specialists trained for specific equipment configuration. Thus, such knowledge ends up restricted to that small group of people and out of reach of the managerial staff. Nevertheless, the lack of management of automation production leads to risks that are inherent to the activity and often neglected. Furthermore, as the automation implanted for a given project itself develops into a long term managerial problem (maintenance). It leads to more specific risks that go beyond the construction period.

In the early years of Information Technology IT, there was alittle need perceived of investment in automated code management in relation to computer software development. As early software systems were developed, documentation and control of the "current version" was most often accomplished as a de-facto manual configuration management [1]. Nevertheless, as the size and complexity of software development increased in recent years it is not uncommon to find large projects with million of lines and several hundred software engineers involved. Companies cross the barriers introduced by distance, cultural differences and time

zones looking for the most skilled personnel and most cost-effective solutions [2]. This activity, with more than one developer working on the same files concurrently is termed parallel development and demands more care with versioning of files. The challenge in managing software development is scaling the change process up to large numbers of possibly geographically-distributed software developers without sacrificing quality or introducing undue overhead [3]. In order to manage such project, some sort of revision control system is necessary [4]. Versioning files and managing modifications has become an end in itself since during most of a system lifecycle engineers have to deal with a growing number of versions of a single component, and to rebuild the complete system in different ways [5].

Industrial Automation has not accompanied the development rate of IT, but nevertheless is experiencing a more accentuated growth in both size and complexity in recent years. The difference from IT is the finality of the configuration files. While in IT plain text programs are stored and controlled, industrial automation manages the versions of configuration files for Programmable Logic Controllers PLCs, Digital Relays, Communication Cards, Intelligent Actuators or any other equipment with built-in configurable intelligence. In large industries, developers are often located at several geographically distributed sites each having automation elements that are becoming highly configurable. It is then not strange that industrial automation professionals turn to IT in search of tools for controlling this new scenario that is presenting itself. Several papers have analyzed, from the IT point of view, the problem of working with several developers in different geographical locations, which are fully applicable to industrial automation. As an example, CARMEL and AGARWAL [6] studied how the effects of geographical distance and consequently cultural discrepancies could affect production and proposed a few tactics to overcome them.

2. Objetive

Throughout this paper the authors aim to determine the risks involved in managing industrial automation files in the pipeline industry as well as the needed actions to apply the avoid, mitigate, transfer and accept strategies. As a further development, the authors assess the response given by PETROBRAS Transporte S/A - TRANSPETRO to such risks associated software management activities.

3. Materials and methods

For the development of the current text, a group of engineers were assembled. This team was made responsible for the risk analysis of the industrial automation software management and was comprised of the following professionals:

1. Automation specialist - Mechatronic Engineer – PETROBRAS Transporte S/A – São Paulo
2. Automation specialist – Electric Engineer – PETROBRAS Transporte S/A – São Paulo
3. Management specialist – Civil Engineer – PETROBRAS Transporte S/A – São Paulo

The risk analysis team visited most of the areas and talked to several professionals in order to assess the problems inherent to industrial automation. Once completed this series of unstructured interviews, a survey was elaborated in order to validate the risk analysis. With the results of the survey, the same team of engineers performed a detailed analysis in order to assess how the response actions impacted the industrial automation activities.

4. Results

4.1 Risk analysis – PETROBRAS Transporte S/A - TRANSPETRO

The first step in solving a problem is to acknowledge the existence of the problem and measure its impacts on production. Software management is often seen as a secondary need when compared to more money/time demanding activities. Moreover, as this activity is performed by technicians and engineers with specific training, it becomes a niche inside the company that outsiders rarely interfere. The problem resides in bringing management concepts to the programming staff that generally has a more result oriented posture and do not perceive management as a problem nor is willingly to apply those concepts to their activities.

Through the experience and past results of PETROBRAS Transporte S/A – São Paulo, the management personnel detect that industrial automation is effectively impacting on its projects and activities. Therefore the authors were involved, along with some of the company´s own automation staff, to assess and map the problem.

In order to achieve the desired results, a lifecycle model was developed in order to assess what kind of risks each step of an industrial automation project are relevant and effectively important (Fig. 1).

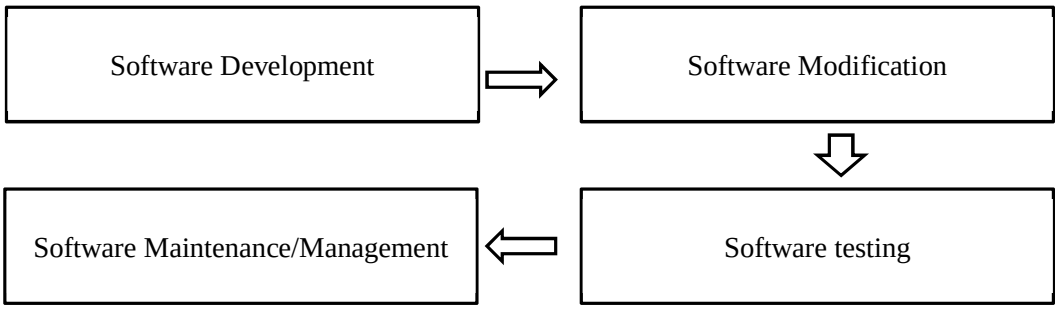

Figure 1- Software development lifecycle

In Figure 1 it was detected that software management includes four main groups as far as industrial automation is concerned: a development group in which new software is created; a modification group in which existing software is altered either receiving new features or removing old ones; a testing group in which the alterations are tested before being handed to the maintenance crew and a management group in which the everyday maintenance activities are contained and the managing of new software projects. It can be perceived that the Software Development, Modification and testing experience very similar risks from the software management point of view. In Table 1 it can be seen a summary of such risks as determined by the analysis group.

Table 1 - Software development risks

Risk	Cause	Rate	Impact	Response
Delay/Failure to comply with the timeframe	Difficulties in determining the last official version of a given program	Very high	Very high	Automated versioning system
	Programming crew bad management in divulging the current files for all people involved	Very high	Very high	Provide technician to accompany all activities related to software development
	New software based on non-current versions of existing programs	Very high	Very high	Allocate experienced automation professionals in managing crews when the cost prediction and timeframe are determined

Risk	Cause	Rate	Impact	Response
	Files not made available by system managers due to bad managing	High	Very high	Allocate experienced automation professionals in managing crews for correctly determining the need activities
	Technician responsible for the equipment employment terminated	Low	High	Plan and update costs and deadlines as the project advances
	Files not made available by system managers due to production reasons	High	Very high	
	More than one crew working on the same equipment at the same time without control	High	Very high	
	Resources such as trained personnel, computers and configuration programs not available	Low	Very high	
Rework	Failure to share new software solutions	High	High	Automated versioning system
	Lack of software standards	High	High	Provide a technician to accompany all activities related to software development
	Failure to divulge software standards among the company personnel as well as the outsourced crew	High	High	Provide password protection and cryptography to automation files need by outsourced companies
	Failure to register off schedule interventions	High	Very high	
	Technician responsible for the equipment employment terminated	Low	Very high	
	Files not made available by system managers due to bad managing	High	Very high	
	Outsourcing without the proper accompaniment	Low	Very high	
	More than one crew working on the same equipment at the same time without control	High	Very high	
Unintentional technology transferring	Uncontrolled use of standardized blocks of software both by in-company and outsourced employees	High	Very low	Automated versioning system
	Uncontrolled access of outsourced personnel to the company´s software repositories	High	Low	Provide password protection and cryptography to automation files need by outsourced companies
Failure in managing HSE software	Failure to register when HSE features are removed from the	High	Very high	Provide a technician to accompany all activities related to software

Risk	Cause	Rate	Impact	Response
related itens	software			development
	Failure to keep the history of changes made to the automation files	High	Very high	Provide specific training to the professionals involved both outsourced and in-company.
	Outsourcing without the proper accompaniment	Low	Very high	
	Inadequate plan of interventions	High	Very high	

Obviously, not all risks listed are present in Table 1, but one can get a general idea especially as the response actions are grouped in very few different activities. In Table 2 it can be observed a few of the risks and the correspondent assessment for the management phase.

Table 2 - Management Risks

Risk	Cause	Rate	Impact	Response
Failure to comply with the budged	The company´s software standards are not properly divulged among the workforce	Very high	High	Automated versioning system
	Workforce is not familiar with ready-to-use code available	Very high	High	Allocate experienced automation professionals in managing crews when the cost prediction and timeframe are determined
	Planners are not familiar with the complexity of the company´s current programs	High	Very high	Allocate experienced automation professionals in managing crews for correctly determining the necessary activities
	Lack of exerienced programmers	Low	High	Plan and update costs and deadlines as the project advances
Failure to comply with project deadlines	The company´s software standards are not properly divulged among the workforce	Very high	Very high	Automated versioning system
	Workforce is not familiar with ready-to-use code available	Very high	Very high	Allocate experienced automation professionals in managing crews when the cost prediction and timeframe are determined
	Planners are not familiar with the complexity of the company´s current programs	High	Very high	Allocate experienced automation professionals in managing crews for correctly determining the necessary activities
	Lack of exerienced programmers	Low	Very high	Provide specific training to the professionals involved both outsourced and in-company.

Risk	Cause	Rate	Impact	Response
Failure to register the history of modification	Lack of management of digital files	High	Very high	Automated versioning system
	Management responsibility shared among more than one team	Very high	High	Allocate experienced automation professionals in managing crews when the cost prediction and timeframe are determined
	Management server failure	Low	Very high	Allocate experienced automation professionals in managing crews for correctly determining the necessary activities
	Corporative network failure	Low	Very high	
	Use of volatile repositories such as pen-drives and emails	Very high	Low	
	Automated backup-up system failure or non-existent	High	High	
	Management staff non-existent	High	High	
	Management responsible not appointed	High	Very high	
Failure to describe the activities needed through the contracting phase	Lack of exerienced programmers	Low	Very high	Automated versioning system
	The company´s software standards are not properly divulged among the workforce	Very high	High	Provide technician to accompany all activities related to software development
	Workforce is not familiar with ready-to-use code available	Very high	High	Allocate experienced automation professionals in managing crews when the cost prediction and timeframe are determined
	Planners are not familiar with the complexity of the company´s current programs	High	Very high	Allocate experienced automation professionals in managing crews for correctly determining the necessary activities
	History of modifications is not efficiently divulged	High	Very high	
Unintentional transferring of technology	Uncontrolled use of standardized blocks of software both by in-company and outsourced employees			Automated versioning system

Risk	Cause	Rate	Impact	Response
	Uncontrolled access of outsourced personnel to the company´s software repositories			Establish procedures to handle outsourced software development and protect the company´s intellectual property when transferring automation files.
				Provide password protection and cryptography to automation files need by outsourced companies

It is important to note that, although the tables 1 and 2 do not present the complete set of risks identified, they can lead us to one interesting fact. No matter what are the risks involved, the response actions can be always grouped in:

1. Automated versioning system;
2. Provide technician to accompany all activities related to software development;
3. Establish procedures to handle outsourced software development and protect the company´s intellectual property when transferring automation files;
4. Provide password protection and cryptography to automation files need by outsourced companies;
5. Provide specific training to the professionals involved both outsourced and in-company;
6. Allocate experienced automation professionals in managing crews when the cost prediction and timeframe are determined;
7. Allocate experienced automation professionals in managing crews for correctly determining the necessary activities;
8. Plan and update costs and deadlines as the project advances;

Furthermore, one more aspect that can be perceived is that the first set of actions, to create and maintain an Automated Versioning System appears as a possible response action to all risks listed.

4.2 Case study – PETROBRAS Transporte S/A - TRANSPETRO– São Paulo

After completing the first task and elaborating a complete risk analysis of the industrial automation software activity, the next logical step taken was to verify, in a company, how the risks listed are perceived and treated. Therefore, in order to assess the validity of the risk analysis and the efficiency of some of the response actions taken by PETROBRAS Transporte S/A - TRANSPETRO– São Paulo, the authors conduct both a structured survey among industrial automation professionals and un-structured interviews with a few of the system maintainers. The survey comprised of professionals involving the industrial automation staff both from the maintenance and engineering sectors. As a consequence, a small but representative quantity of respondents was obtained. The first step of the research was to characterize the respondents (Table 3 and 4) in order to secure representativeness.

Table 3 - Respondent field distribution

Field	Answer	Qty.
Industrial Automation	66,7%	6
Maintenance	22,2%	2

Operation	0,0%	0
Engineering	11,1%	1

Table 4 - Respondent level of education

Level of education	Answer	Qty
Engineer	55,6%	5
Technician	33,3%	3
Other	11,1%	1

It is important to note that, because of the company´s culture, the company´s employees understand that when they declare that they work with Industrial Automation, it means that they are responsible both for project development and field implantation. The survey was also successful in securing only industrial automation personnel were taken as respondents. The next questions were aimed in verifying how the group perceive risks and if the solutions proposed in the study are in line with the thoughts of the people involved with the activities.

Table 5 - Perception of risks and response actions

Question	Option	Answer	Qty
The accompaniement of a company´s trained industrial professional of field work is important to a healthy development of the activities?	Strongly agree	77,8%	7
	Agree	22,2%	2
	Neutral	0,0%	0
	Disagree	0,0%	0
	Strongly disagree	0,0%	0
Failure to correctly estimate the activities cost and deadlines is a cause of problems during the execution of automation activities?	Strongly agree	100,0%	9
	Agree	0,0%	0
	Neutral	0,0%	0
	Disagree	0,0%	0
	Strongly disagree	0,0%	0
The engineers and technicians responsabile to the elaboration of contracts lack the proper industrial automation knowledge resulting in later problems in the field?	Strongly agree	22,2%	2
	Agree	33,3%	3
	Neutral	44,4%	4
	Disagree	0,0%	0
	Strongly disagree	0,0%	0
Off-schedule demands are among the most stressful activity that is performed by the industrial automation personel?	Strongly agree	66,7%	6
	Agree	33,3%	3
	Neutral	0,0%	0
	Disagree	0,0%	0
	Strongly disagree	0,0%	0

The table 5 demonstrates that the risk analysis is coherent with the perception of the industrial automation personnel. Among the results is important to perceive that off-schedule demands is the most stressful activity performed with 66,67% of the respondents strongly agreeing with the affirmation. The other 33,33% also agree with the affirmation, although not strongly. This situation led to efforts towards the implantation of an automated versioning system [7]. This information associated to the fact that was clear in the risk analysis that an automated versioning system would help avoid or mitigate every kind of risk. The same group of people

responded the questions on Table 6 aiming a measuring the importance of this automated versioning system perceived in values.

Table 6 - Automated versioning system

Question	Option	Answer	Qty
Do you consider that a automated version system is necessary control the production of files and their maintenance?	Yes	100,0%	9
	No	0,0%	0
The lack of a automated versioning system is one of the causes of rework?	Strongly agree	77,8%	7
	Agree	22,2%	2
	Neutral	0,0%	0
	Disagree	0,0%	0
	Strongly disagree	0,0%	0
What is the importance you perceive regarding maintening a accurate history of digital industrial automation files?	Extreme importance	22,2%	2
	Very important	77,8%	7
	Important	0,0%	0
	Somewhat important	0,0%	0
	Not at all important	0,0%	0
Communication among the different groups of industrial automation engineers and technicians aids in the production of software solutions	Strongly agree	88,9%	8
	Agree	11,1%	1
	Neutral	0,0%	0
	Disagree	0,0%	0
	Strongly disagree	0,0%	0
Communication among the different groups of industrial automation engineers and technicians aids to increase the safety of the facilities	Strongly agree	100,0%	9
	Agree	0,0%	0
	Neutral	0,0%	0
	Disagree	0,0%	0
	Strongly disagree	0,0%	0

From the results shown on Table 6, it is clear that an automated versioning system is something desired by the industrial automation personnel. As such versioning system, called GIT-TRANSPETRO was implemented in 2013 [7], its impact is measured in the question present on Table 7 and 8.

Table 7 - Perception before GIT-TRANSPETRO

Question	Before GIT - TRANSPETRO				
	very good	good	avarage	poor	very poor
Application control	0,0%	0,0%	22,2%	77,8%	0,0%
Application access	0,0%	0,0%	44,4%	44,4%	11,1%
Reliabitly of the information	0,0%	0,0%	66,7%	22,2%	11,1%
History registering	0,0%	0,0%	33,3%	33,3%	33,3%
History access	0,0%	0,0%	33,3%	33,3%	33,3%
File modification registering	0,0%	0,0%	33,3%	33,3%	33,3%
Safety level	0,0%	0,0%	33,3%	44,4%	11,1%

Information securety	0,0%	11,1%	22,2%	55,6%	22,2%
Overall impression of the software management	0,0%	0,0%	44,4%	33,3%	22,2%

Table 8 – Perception after GIT-TRANSPETRO

Question	After GIT - TRANSPETRO				
	very good	good	avarage	poor	very poor
Application control	77,8%	22,2%	0,0%	0,0%	0,0%
Application access	66,7%	33,3%	0,0%	0,0%	0,0%
Reliabitly of the information	55,6%	44,4%	0,0%	0,0%	0,0%
History registering	44,4%	55,6%	0,0%	0,0%	0,0%
History access	44,4%	44,4%	11,1%	0,0%	0,0%
File modification registering	55,6%	44,4%	0,0%	0,0%	0,0%
Safety level	55,6%	44,4%	0,0%	0,0%	0,0%
Information securety	44,4%	22,2%	33,3%	0,0%	0,0%
Overall impression of the software management	66,7%	33,3%	0,0%	0,0%	0,0%

As expected, one can perceive (Tables 7 and 8) that the implantation of the automated versioning system increased several areas of the industrial automation “environment”.

5. Conclusions

Throughout this article, it was successefully established a coherent lifecycle system to model the management of industrial automation software development. Furthermore, the lifecycle was developed into a full risk analysis which is useful as a guide to companies interested in providing treatment to industrial automation software related risks.

The risk analysis results were put to the proof through the means of a survey among industrial automation professionals of a Brazilian pipeline company, PETROBRAS Transporte S/A – TRANSPETRO. The results of the survey indicate that the risk listed on the risk analysis is coherent with what is experienced inside the company. Moreover, TRANSPETRO´s actions are aligned up to point with the suggested response actions. Particularly the automated versioning system, exposed in the risk analysis as a high impact action, is greatly advanced in the São Paulo reginal.

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