A technology shift for a fireworks controller

P. Vrignat\(^{(1)}\), J.F. Millet\(^{(1)}\), F. Duculty\(^{(1)}\), S. Begot\(^{(1)}\), M. Avila\(^{(1)}\)

\(^{(1)}\)Institute of Technology – PRISME Laboratory – 2 av. François Mitterrand – 36000 Châteauroux (France)

+33(2).54.08.25.50 – pascal.vrignat@univ-orleans.fr

1. Introduction – In the past, wands with polder were used to fireworks ignition. But the proximity of the operator with the explosive tubes (or parts) was very dangerous and needed a new system more safety. Nowadays, ignition of each tube or explosive device is made from a firing case, located near the management place, using electrical igniter [1]. These igniters provide to convert electrical power in a flame which ignites mortar tube. Igniters are connected to the firing system by electrical wires called shooting wires. To provide easier network of shooting wires, which may be complex, it is possible to add electrical relays in this network to reduce the number of connections rising management place. Then, the manager selects a wire and demands ignition of selected mortar tube. This kind of classical design needs a lot of time to installation and uninstallation (Image 1). More difficulties can be added like: presence of water, high installation... This kind of solution is also expensive with shooting wires (copper electrical wires). Once uninstalled, electrical wires cannot be reused. Recycling needs to be done. Image 2 shows a "classic" solution and the "new" solution to be found.

1. Genesis of the project. How does this collaboration started with a manager who has Ruggieri certificate? – Projects conducted since 1996, are related with professional expectations of our training courses and are often carried out in partnership with local industrials [6]. Since then, we have an average of two to three industrial collaborations per year. Although we cannot guarantee optimal results for these collaborations, as the main actors of the project are training and these projects are often their first experience in relation to the working environment. We aim to guide our students toward a consistent set which includes a technical achievement based on a product, with document management, budget management... and, of course, writing of requirement specification to satisfy customer needs. Our strategy in project management, is identical with our DUT\(^{1}\) and LP\(^{2}\) students. The difference is on time.

\(^{1}\) DUT : second year of Bachelor Degree
\(^{2}\) LP : Professional Bachelor Degree
passed on these projects: 96 hours by DUT student, 150 hours by LP student. At the beginning of the academic year, we provide a lot of information to students: calendar organization (with milestones), evaluation process (work, activity report, presentation), one sheet description of projects (Image 3). Then, students can select an ordered list of projects. According to this list, the project "A technology shift for a controller fireworks" could begin with students.

2. Cost, time, performance - This work needs a coherent organization over several months. Three students have worked on the project during the period from September to March. Two teachers supervised students. A final internship study for a student was planned to finalize works that remained to be done (Photo 1). The delivery of the solution to the customer took place in the last day of May. The overall cost for this version amounts to € 1,700.

2. Experimental and results – Proposed solution, which was validated by the customer, is shown in the Image 4. This solution uses radio frequency technology (Xbee-Pro) based on Arduino Single-Board Computer (SBC Arduino [2]). An important work of CAD had to be conducted to create all the interfaces compatible with Arduino adopted solution.

These works require to develop PCB (Printed Circuit Board) prototypes for the Arduino SBC. This PCB is the result of an important work of design to provide connexions for all the inputs and outputs of the installation (Image 5). The files for the production were created using the Cadence software. PCBs were manufactured by Eurocircuits company under our specific recommendations [4].

Image 4. Validated solution

Image 5. PCB creation for inputs and outputs

Image 6. Results
Image 6 shows the construction of the two suitcases that will be devoted to shooting fireworks. These little bulky suitcases, respect constraints that had been expressed in the requirement specification. Programming of the solution was split in two parts. The first part consists in programming each radio XBee-Pro module. This programming was performed with the X-CTU software [5]. This program was designed to declare the logical addresses of the two XBee-Pro modules. The second part consists in programming in C language and individually, each Arduino board with the builder programming environment. The flow chart (Image 7) shows operating principle for suitcases.

4. Conclusion – These works need a lot of hours spent to search the optimal solution considering limited financial cost (nearly 2,000 euros) and various technical constraints. All constraints of the project were defined with drafting the technical specifications [6]. The first fireworks has be shot ten months after the study.

The customer is very satisfied with the work done and wishes to continue the research for a complementary solution. This next solution will be able to control two new reception suitcases. Under these conditions, the manager can control 150 rockets departures.
5. References
[1] Decree No. 90-897 of October 1, 1990 on the regulation of fireworks