

# *COVID-19 as a Stimulus for Remote Manufacturing Efforts*

*Giselle B. Montano Caraballo  
Master in Manufacturing Competitiveness  
Dr. Rafael Nieves Castro  
Industrial and Systems Engineering  
Polytechnic University of Puerto Rico*

---

**Abstract** — *The Island of Puerto Rico currently encounters the same issue as the rest of the world but does not count with the proper technology in manufacturers to confront it Remote operations of manufacturing systems are needed now more than ever. With the current world pandemic, it is essential today to reduce human interaction in workplaces such as manufacturers. Manufacturing floors in search of this objective should rely on computer-oriented employees and systems that assist the manufacturers objectives with automation, robotics, and computer programming. The previous mentioned are systems that are in current use worldwide but should play a bigger role in Puerto Rican manufacturers. It is important that Puerto Rico manufacturers get more digitalized and remote to assist workers safety.*

**Key Terms** — *COVID-19, remote manufacturing, remote office, remote work*

## **INTRODUCTION**

The design to be researched consists of a proposing high efficiency systems and tools for manufacturing areas in Puerto Rico. Such tools, systems, and equipment to be researched will assist on orienting manufacturers on controlled by remote operations with secure online network connectivity and online connected workers. This investigation will be of benefit for manufacturing companies for assisting the health and safety of their employees and the people that surround them. One objective is to seek to propose monitoring operations on manufacturers to be covered mostly by efficient remote systems and solutions rather than human direct interaction [1]. This investigation will assist with the implementation and motivation of manufacturing companies in Puerto Rico to operate on remoted systems. Operations need to be accurate, transparent with high use of quality

sensors, cameras and secure networks of hardware products and software products. With this investigation it is expected to seek the best factors for the previous mentioned components. Develop and propose a plan for manufacturers in Puerto Rico to design manufacturing stations and floors that reduce the exposure of physical human hands-on intervention with machinery to achieve social distancing. A reduced workforce in site means less waste and additional worker safety thanks to digitalization and automation.

## **Research Objectives**

There are three research objectives:

- **First:** To present that increasing remote manufacturing in Puerto Rico by 50% means a decrease of manufacturer on-site personnel. For such balance to be obtained, high quality remote controls on manufacturing areas are needed and maintained. Remote controls generate the opportunity of less on-site technical staff supervision, increase on safety measurements and less physical monitoring of hardware and software equipment that can be migrated to be examined from a remote station at a glance thanks to the influence of the internet of things.
- **Second:** To suggest the use of three tools that support remote operation environments that can be applied to manufacturing area hardware or software. To suggest tools that assist remote environment on manufacturing floors for software and hardware systems. Hundreds of tools for remote environments exist today, but modern, reliable, and economic options will be proposed and recommended ahead.
- **Third:** To propose a general experimental plan for manufacturers in Puerto Rico to migrate into remote technologies. Digitalization on

manufacturing areas is cutting edge improvements that will assist current world issues that impact Puerto Rico regarding social distancing.

### Research Contributions

There are three research contributions:

- **First:** “In addition to remote control it is now possible to install remote monitoring systems. This is more appropriate to continuously running plant but a large standby generating set without the benefit of supervision from on-site technical staff may well deserve a degree of monitoring. Basic monitoring may include data such as starter battery condition, start and stop times, power, voltage, speed, exhaust temperature for each cylinder, jacket water temperature, oil pressure, engine room ambient temperature, and vibration. If any of the readings do not fit into the expected pattern a warning is given to the appropriate person or persons. It is not necessary for monitoring to be continuous, data can be scanned periodically, say at 10-min intervals.” [2].
- **Second:** “Remote clients are connected to the lab server via remote access tool. Radmin tool is used for the implementation as it is best suited for real time applications. User interface is developed using LabVIEW on the server machine which communicates and controls the test instruments and interface hardware...” [3].
- **Third:** “In transition from classical and traditional to modern manufacturing systems, a number of key improvements have occurred, including the ability to control a machine remotely, over the Internet.” [4].

### LITERATURE REVIEW

The COVID-19 world pandemic has offered room for improvement and revolution of the digitalization of many hardware and software systems. Maintaining the ‘business as usual’ mentality thought the COVID-19 is an approach all service and product businesses in Puerto Rico are

taking profoundly serious to achieve success even in these hard times for worldwide economy. Avoiding the negative effects of the pandemic is part of the objectives of remote working during such times even in manufacturing floors for manufacture industries to maintain concentrated on the mission and objectives of the organization. The pharmaceutical industry has only been in Puerto Rico for the past 67 years [2]. Manufacturers in Puerto Rico play an important role for the Islands economy since for example, back in 2006, the islands drug manufacturers had United States as the main consumer for 80% of the production [2].

In response to COVID-19, manufacturers in Puerto Rico have adapted to the situation by shrinking personnel numbers as well as establishing limitations on budget. Obstruction on software and hardware resources have also arisen. The constant stress, difficulties and issues born with COVID-19, have been also chance for optimism as manufacturers can see this as a chance to speed up the digitalization of manufacturers and introduce remote and virtual technologies. Back in 2007, it was stated that “There is not an integrated system that can fully utilize the feature of networked virtual manufacturing technology in product design and manufacturing” [3], but although not having the ability of full capacity on remoting or virtual networked technologies, holding to the chance of digitalizing a portion of the system being remoted, grants a relief for the limitations presented by the current pandemic of having less human-to-human interaction on site.

Remote controlled manufacturing floors might include the use of web-based integrated systems and networks that can be accessible from employees’ homes with secured connections or Virtual Private Networks (VPN) [5]. The use of such off-site technologies, access and systems allow the design and part of the manufacturing effort to be from anywhere geographically [6]. To accomplish a higher demand, the concept of remote manufacturing in Puerto Rico, manufacturing equipment needs to include integrated capabilities to securely receive and transmit data via internet

internally and externally to the manufacturing floors. Another factor to be aware of is that “Time delay on the internet can distort the control and feedback information, resulting in the instability of the whole remote-control system.” [7]. Remote controlled manufacturing is generally full of advantages as it might include lowering operating and monitoring costs of hardware and software systems, less personnel and less human interaction on site.

## METHODOLOGY

To assemble a plan that enforces remote work in a manufacturing floor during a pandemic can be comprehensive and complicated work that demands to be accurate for the benefit of the manufacturer personnel and moreover, for their communities. Establishing a COVID-19 cooperating strategy can be plenty of work for manufacturers to come together into reaching the goals of a safe workspace. Depending on the current hardware, software, and floor plan that the manufacturer counts with, different measurements for reshaping the work areas might be needed. Apart from reshaping the physical areas, adapting the personnel to the transmutation of remote work is highly necessary. Achieving the goals that this article advices can be accomplished with a series of hardware, software, processes, and practices that need to be implemented into daily exercises by the employees and management.

To begin with, lowering the in-site personnel can be replaced with active monitoring using security cameras and webcams. Since “more than 66% of manufacturers use the technology storage and transit via the cloud”, nowadays it is safe to obtain a provider that assists the net of data from the site to the workers’ home. Media use such as video, shall be installed in more areas of the manufacturing machinery or systems. This can allow workers to remotely monitor the manufacturing floor and alarm the site if something goes wrong, so that personnel that is currently at the site can take the appropriate actions. Personnel that is at the site, needs to be properly trained to act

as backup and take actions that they would not be normally responsible for. Personnel that is currently at the site needs to maintain constant and clear communication with their remoted peers in order to keep the manufacturing floor safely functioning. There are in fact areas, tasks, projects that do not require personnel to be on-site. These workers should be selected to do remote work instead of being present at the manufacturer. For lines that need personnel in a day to day basis, but do not operate on the 3 shifts, it is recommended that the implementation of additional shifts are created so that products continue to be elaborated but with less personnel on the floor at the same shift. These workers shall be trained on tasks they would normally not be assigned to so that they can start being responsible for additional or different duties in such new shifts. It is important for management to be aware of nationwide curfew and hand their employees the proper company permissions and authorizations that can be shown to government officials if they are intervened during curfew hours due to work responsibilities. There are many tools available today that support remote working and that should be implemented and normalized across all manufacturers in Puerto Rico. Cloud services such as the ones provided by Google or Microsoft serve as great transporters so that data and information can flow from the site to the workers remote office area. Companies can provide incentives or assistance for helping their workers obtain internet service at their remote office area if needed and depending on the workers situation. A tool for remoting into computers at a distanced network recommended is Radmin, which offers a server side and a viewer client.

Not only reducing personnel on site, or applying new shift hours with less personnel each, normalizing the use of remote tools, but maintaining the 5S mentality is key to prevent the spread of COVID-19. Utilizing this methodology during the pandemic is essential. Taking the actions to sort, straighten, shine, standardize and sustain practices are more important to follow now than ever at the site and at the remote office location. By

eliminating or removing all the materials and tools from work areas that are not intended to perform business that is essential helps reduce the amount of surface area for the virus to spread. For tools and materials that have been in contact with personnel, it is needed for it to be cleaned and disinfected. Those materials that have been in use, shall be divided up into designated areas for cleaning. Such designated cleaning area reduces the risk of an employee to accidentally encounter and have contact with tools or materials that have been contaminated. Those mentioned recommendations are part of the sort efforts of the 5S methodology. As part of straighten, employees are to make sure that all the required materials and tools are properly labeled as clean or not-clean with illustrations that are not visually blocked. The most important of such practices during this pandemic is to shine, since this practice includes cleaning everything that is used during essential operations. All workstations, tools and common areas that workers come into contact with need to be cleaned and disinfected to effectively reduce the risk of the virus to spread. As part of the initiatives for standardizing, is to implement a workflow in the manufacturing floor and other common areas that is easy to understand and employees to follow. As the last recommendation using the sustain topics on the 5S methodology is to have these measurements be the new normal, a sustainable routine for cleanliness and organization. Performing tasks with such practices in mind for every employee, will assist the prevention of sickness during this pandemic of future outbreaks.

## **RESULTS AND DISCUSSION**

Teleworking is referred to the use of telecommunication aided facilities for the improvement of human-to-human remote collaboration while enhancing equipment and processes to improve performance [8]. It is important providing teleworking solutions to the issues originated in Puerto Rican manufacturer industries caused by the COVID-19 pandemic is a

constant changing work since unexpected variables can continue to arise. For a few of those changing variables, results and suggestions are to be provided following this article. As a result of the lack of community response on the pandemic, industries and workplaces need to develop their own guidelines of pandemic feedback. Apart from guidelines that promote individuals' behaviors, industrial processes and manufacturing floor environments need their dedicated technical guidelines and rulesets dependent of risk levels.

This experimental plan developed by each company and manufacturer should include information regarding the responsibilities of the site leader, human resources, management and employees including contract workers. This plan needs general facilities information that includes a site overview. The most important section shall include the topics on the actual plan and processes that have been addressed as an action to assure healthy personnel to visit and work at the site. The plan needs to be updated with regards to local government restrictions and requirements that are current, therefore the developed plan should be revisited in a weekly basis so that it can be updated as needed in an urgent manner. A plan for a future normal return to work needs to be addressed or at least drafted including special considerations for workers with delicate cases. The plan needs to be linked to the Occupational Safety and Health Act (OSHA) regulations and guidance [9]. Protocols as to physical controls needs to be determined and described in the plan. These should include site entry protocols, Personal Protection Equipment (PPE) mandates, area and tool disinfecting equipment and plans, physical space utilization, individual travel flow and path, ventilation and filtration requirements and support of other contractor services such as maintenance, security and cafeteria personnel. Also, a plan for monitoring suspected cases needs to be defined. Each manufacturer is responsible for the correct communication strategies for on-site and off-site remote personnel. A plan for training is necessary if is determined that employees are in necessity of it.

The COVID-19 driven guidelines to be presented to all employees of manufacturing floors in Puerto Rico must prepare the personnel with the basic infection prevention measurements. The plan should promote frequent handwashing, stay at home mandates if symptoms arise and the use products that allow SARS-COV-2 disinfecting on tools and areas. Guidelines shall be offered to encourage respiratory etiquette and maintain 5S at the home office. The manufacturer leadership shall explore practices and policies that might need to be modified to allow flexible work hours and worker distance increment [10]. It is important for all facilities to discourage tool and equipment sharing and a plan for the proper tool and equipment handling.

An overview of how Radmin's features, pros and cons can be analyzed and described in this section. Expand information on remote clients, virtual networked technologies, virtual private networks (VPN). The Radmin software is a provider of high-speed communication that can be very useful at the time of telecommuting [11]. This system allows connection of a remote computer multiple client computers or the other way around. Radmin is suitable for devices that use the Windows Operating System (OS). Other features include keyboard locking, full remote access and controlling, screen monitoring, screen recording, file transfer and copy/paste along connected server and client. The software plans and pricing include a one-time fee that include license, upgrades, setup tools and technical support.

The pros of this software include 2,048-bit key size that allow user authentication. This software is highly recommended for current use at industries since the connections are secured with 256-bit encryption for all data that is transmitted. The minimal-lag system offers special keystrokes and high-resolution displays that allow for a smooth teleworking experience. The cons include having the need to know the Internet Protocol (IP) IP address to configure the desired Personal Computer (PC) connection. A disadvantage of the service is no live support or phone assistance on some service

packages, so for companies to obtain full service, greater monetary investment is expected. Configuring the actual connections might not be as intuitive as expected, but with the proper guidelines that are equipment specific, team-members could experience an easy system configuration experience.

For industrial automation and machinery, MATLAB and Simulink provide personnel with the tools to develop production systems that control industrial equipment and Programmable Logic Controllers (PLC) [6]. With the mentioned software, design machinery controls and testing them in a virtual manner is possible. Running automatic test scripts using this system with a combination of the previously described Radmin is a good combination for remote work. Virtual commissioning is possible with MATLAB and Simulink so that personnel can simulate, test and verify the model systems, plant floors and even components with scripts before doing actual production. A con that provides MATLAB/Simulink is that this product can reside at servers or at the cloud and it can be integrated with other software. Model-based design approaches are recommended as part of the modernization of the manufacturing equipment and software systems as they promote characteristics for teleworking. Interoperability of such systems and software packages on remote and onsite network computers promote a fluid remote work experience to avoid personnel present at the physical sites.

## **CONCLUSIONS**

### **Most Important Findings**

The COVID-19 outbreak in a workplace can affect in many negative ways that can interrupt supply and delivery shipments, increasing personnel absences and a change of demand patterns. The pandemic can bring some positive technological improvements on the hardware and software that supports the industry or manufacturer equipment that promote digitalization,

automatization, internet network security protocols and equipment modernization. A defined pandemic response plan needs to be developed by each manufacturer that resides in Puerto Rico to provide specific guidelines on technical and non-technical procedures that adhere to the site or manufacturing floor.

### Limitations

The proposed usage of the mentioned software systems come at a monetary price. Free trials can be installed but are not recommended as they tend to expire. Investment of such systems and software is needed to allow for installation and operation of telework. With the fast-response environment due to the pandemic, manufacturers need to make quick quotes, acquisitions, installations, configurations, and knowledge base for personnel that has been selected to telework.

### Summary of Contributions

- Offered the plan topics that shall be included in the developed guidelines and plans that can be adhered to site-specific responses against the COVID-19 pandemic.
- Recommended software and software methodology that can currently support manufacturing equipment for teleworking capability.
- Comparison of software that provide and promote remote controls on computer-controlled equipment has been delivered.
- Demonstrated examples of major improvements of migrating to remote work that avoid health issues related to the COVID-19 pandemic of manufacturing floors and sites in Puerto Rico.

### Future Research

Include articles of how manufacturers reacted to the pandemic and how did it affect the production and revenue of the company. Future research could include the plan of a possible fixed or combined remote work plan for companies or sites that did not exercise such methods pre-

pandemic. Detailed examples of the comparisons of the above-mentioned systems and software for remote equipment controlling can be studied and presented on future research. Comparisons of personnel performance that are physically on-site versus teleworking employees can be quantified on future research when companies adapt such measurements. A deeper quantitative study and quotation can be evaluated for manufacturer digitalization cost depending on personnel and site limitations is of great interest to be presented in a future.

### REFERENCES

- [1] A. C. King and W. Knight, *Uninterruptible Power Supplies and Standby Power Systems*. New York, London: McGraw-Hill, 2003.
- [2] K. C. Richards, "Puerto Rico's Pharmaceutical Industry: 40 Years Young!", *Pharmaceutical Online*, September 20, 2006. [Online]. Available: <https://www.pharmaceuticalonline.com/doc/puerto-ricos-pharmaceutical-industry-40-years-0003>
- [3] Q. Peng, C. Chung, C. Yu, and T. Luan, "A networked virtual manufacturing system for SMEs," *International Journal of Computer Integrated Manufacturing*, vol. 20, no. 1, pp. 71–79, 2007. [Online]. doi: 10.1080/09511920600877494
- [4] V. Spasojević-Brkić and G. Putnik, "User evaluation of the interfaces for the remote control of manufacturing systems," *Serbian Journal of Management*, vol. 8, no. 2, pp. 201–212, 2013. [Online]. doi: 10.5937/sjm8-4281
- [5] A. Kumar and J. Chandra, "Development of remote access and control features for digital signal processing laboratory experimentations," *International Journal of Online Engineering*, vol. 12, no. 08, p. 51, 2016. 10.3991/ijoe.v12i08.5957
- [6] MathWorks, "MATLAB and Simulink for industrial automation and machinery." Accessed: December 5, 2020. [Online]. Available: <https://www.mathworks.com/solutions/industrial-automation-machinery.html>
- [7] F. Qiao, H. Schlange, H. Meier, and W. Massberg, "Internet-based remote access for a manufacturing-oriented teleservice," *International Journal of Advanced Manufacturing Technology*, vol. 31, pp. 825–832, 2007. [Online]. doi: 10.1007/s00170-005-0234-3

- [8] G. Orphanos, D. Kanellopoulos, L. Prentzas, and S. Koubias, "Proposed teleworking platform for workstations supporting multimedia medical applications," in Proc. SPIE 1899, Medical Imaging 1993, September 8, 1993. [Online]. doi: 10.1117/12.152868
- [9] *Guidance on Preparing Workplaces for COVID-19*, U. S. Department of Labor Occupational Safety and Health Administration, OSHA 3990-03 2020, 2020. [Online]. Available: <https://www.osha.gov/Publications/OSHA3990.pdf>
- [10] B. Merton, "How to enable remote work in manufacturing during the COVID-19 crisis," Unifize. Accessed September 3, 2020. [Online]. Available: <https://www.unifize.com/how-to-enable-remote-work-in-manufacturing-during-the-covid-19-crisis/>
- [11] S. Schooley, "Radmin review," Business.com, March 14, 2019. [Online]. Available: <https://www.business.com/reviews/radmin/>