The 9th International Symposium on Automation and Robotics in Construction June 3-5, 1992 Tokyo, Japan

IDENTIFICATION OF HUMAN BARRIERS TO THE SUCCESSFUL IMPLEMENTATION OF CONSTRUCTION AUTOMATION

Ronie Navon[1], Paul W. Kelly[2] and David W. Johnston[3]

[1] Faculty of Civil Engrg. and National Building Research Institute
Technion City, 32000 Haifa, Israel

[2] U.S. Army Corps of Engineers

[3] Department of Civil Engrg., North Carolina State University

ABSTRACT

Many construction experts claim that the construction industry must implement automation and robotics as part of an overall program to increase productivity, safety, and quality, and to remain competitive in the face of growing global competition. The limited experience of applying robots to construction, together with conclusions drawn on the basis of robotic applications in related areas, show that developing efficient robotic systems alone will not ensure successful implementation. Significant resistance was observed in the manufacturing industry, which seriously impeded successful implementation. In addition to this, the conservative nature of the construction industry suggests potentially significant levels of resistance to the introduction of project level automation and robotics. The article reviews some limited introductions of automation into the construction industry and finds evidence of resistance. The sources and the causes of resistance to the introduction of automation and robotics, as experienced in selected manufacturing industries, are summarized. Successful resistance reduction actions, used by these manufacturing industries, are compiled and presented.

1. INTRODUCTION

Automation and Robotics is gradually receiving more attention in the construction industry as a promising means to solve, or facilitate, some of the major problems the industry is facing. It is believed that automation will contribute to increase productivity and improve quality and safety. This belief has led both practitioners, and especially researchers, to develop automated systems for well over a decade, yielding results that can eventually be implemented in the field. The success level of the field implementations will depend on numerous technological and human factors. This article addresses some of the human factors influencing the successful implementation of on-site automation at the project level.

The cumulative experience in various manufacturing industries shows that resistance can seriously impede successful implementation of advanced technologies, in general, and automation and robotics in particular. The construction industry, which is well known for its conservatism, can expect even more extreme resistance. The following statistics illustrate the conservative nature of the construction industry. It takes approximately seventeen years, from the proof-of-feasibility to the adoption of a new technology in the construction industry, while the computer industry is doubling its performance every four years[5].

Resistance to new technologies in the construction industry originates from both subjective and objective reasons. Because of the volatile and unpredictable nature of the environment within which the construction industry operates, the management tends to avoid changes and recourses to the old and proven methods and technologies. Field studies on construction sites have shown that also lower level resistance to changes exists. Workers, foremen and superintendents offer strong resistance to change due to the fact that they are busy and under pressure - they are reluctant to try new methods even if they know that it would cut cost[12].

The inevitable conclusion of the above observations is that the development of sophisticated and efficient automated systems alone will not guarantee their successful implementation. Despite the high technological level of these systems, the construction industry might find itself facing a large implementation failure if it does not anticipate and reduce potential resistance. Consequently, there is an immediate need to develop a management strategy model for anticipating and reducing resistance to automation.

The remainder of the paper describes the research methodology, identifies resistance elements to automation and robotics in manufacturing, and investigates resistance to automation in construction. Finally, it describes some common strategies for reducing resistance to change.

2. RESEARCH METHODOLOGY

The problem of resistance to implement new technologies, in general, and construction automation and robotics in particular, is very wide in scope. Among the many obstacles to successful implemenation are technical, economic, institutional, organizational, social and human barriers. Being one of the first research efforts dealing with the subject of construction automation acceptance, we would like to firstly shed some light on the need to tackle this problem at this early stage, on the one hand, and on the other we attempt to identify the possible causes for, and sources of, resistance and indicate possible solutions to deal with the human aspects of successful application of construction automation.

The emphasis of the research is on the project level acceptance. For the purpose of this research, project level refers to the on-site personnel, namely workers, foremen, superintendents, and up to project managers. An implicit assumption pertaining to other elements of the industry, such as company management, suppliers, sub-contractors, owners and/or clients, federal or local agencies, etc., is made. This assumption is that all the above fully accept construction automation and pose no obstacles on its successful implementation. This assumption, however utopian it may be, is necessary in order to isolate the problem in question.

Because at present construction automation applications are mainly limited to prototypes employed in pilot plants, it is not possible to utilize experience from the construction industry. Consequently, in order to avoid unnecessary delays in pursuing the matter, a different methodology had to be employed. The methodology studied the obstacles to automation in other industries, as well as the barriers to the introduction of other advanced technologies in construction. Consequently, based on that information together with common implementation strategies, a management tool for resistance identification and reduction will be developed. More specifically, the methodology consists of the following stages:

1. A literature survey.

2. Analysis and compilation of the literature survey results. The analysis will consolidate the information gained in the previous stage in order to indicate three issues:
* Who is expected to resist the introduction of automation and robotics?
* The major reasons for such resistance.
* The main elements of common models for implementation of new technologies and/or robotics.

3. Develop strategies and/or models for successful introduction of construction automation and robotics. As direct knowledge of how to overcome resistance to construction automation does not exist, an indirect approach would be beneficial. It is indirect because it is looking either at methods in construction that do not relate to automation, or at methods relating to automation in manufacturing industries other than construction. The development process will be to take

each of the elements found above and to adapt them to the specific conditions prevailing in construction.

4. Model and strategy testing. At this stage attitudes towards automation in construction sites will be measured before and after applying the model. The experiment can either be performed in a synthetic way, by conducting interviews and surveys, or more practically by trying to actually apply an automated system.

This article reports about the first two stages - the literature survey and its analysis. A more comprehensive report is in preparation and will be made available in due course.

3. RESISTANCE TO AUTOMATION AND ROBOTICS IN MANUFACTURING

The literature covering causes of resistance to automation does not lend itself to simple analysis. None of the studies measures exactly the same resistance variables and each organization and automated technology being introduced is unique. However, despite these differences there are some definite trends. The general categories of resistance to automation provide a starting point for identifying those trends and for further analyzing the data. These categories are:

a) Fear of unknown changes or uncertainty - people tend to resist something that they cannot predict or do not understand.

b) Desire not to lose something of value - people tend to resist something they perceive as a threat to what they value.

c) Fear of personal inability to handle new requirements - people who feel they cannot meet challenges of change tend to resist it.

d) Inadequate understanding of need for the change - people tend to resist change if they perceive the cost outweighs the benefits.

e) Poor implementation efforts - inadequate planning of the implementation process itself - inapt user involvement and insufficient training.

f) Labor-management relations - an atmosphere of openness and trust between labor and management is crucial for successful implementation of automation. Lack of such an atmosphere will cause the workers to resist, based on their obstructed concerns.

The first two categories end up being combined into one category in this analysis, because the same things people desire not to lose - jobs, skills, etc. - are the same things in which they fear unknown changes. Figure 1 summarizes the specific causes of resistance to the introduction of automation for different levels of employees under the general category headings.

4. RESISTANCE TO AUTOMATION AND ROBOTICS IN CONSTRUCTION

As mentioned before, resistance to automation and robotic in construction is based mostly on indirect information. This section examines an automation and robotics survey and three case studies. Resistance was not the primary focus of the studies; however, they do cite information concerning actual resistance to the introduction of automation in its broader sense in construction.

A survey was conducted among the top 400 Engineering News-Record contractors to investigate their reactions to automation and robotics in construction operations. The majority of respondents believed that automation and robotics would improve productivity (95%), speed (91%), and quality, safety and competition (77-79%). However, only 15% felt that labor-management relations would improve. In fact, the majority felt they would be worsened. While 84% of the respondents expected mechanization to increase only 38% expected advancement in robotization The survey concluded that construction contractor attitudes, regarding advanced technologies, must be changed toward the positive.

The first case study describes a construction company that moved from manual methods to extensive computerized operations. The company - a mid-size company specializing in commercial buildings - had a variety of microcomputers, both for field, but mainly for headquarters applications. The case study focuses on the company's transition to microcomputer use and the effects of that transition on various company personnel.

Mid-level managers' attitudes toward the microcomputers spanned from fear, total lack of interest, curiosity, excitement, to obsession. Negative attitudes developed when nonusers were not open to seeing how microcomputer applications could benefit them. Some mid-level managers even became hostile toward the "company computer nut", which resulted from the managers' lack of confidence in their own abilities to learn to use computers, or from fear that computers would eventually replace them on the job. Some employees never adjusted to microcomputer use - they were transferred to a non-computer area, and some of them had to be dismissed.

Field use of the microcomputer has been limited to inventory, project cost accounting, job logs, and word processing. The case study observed that field employees were divided between those who were anxious to have a microcomputer on the job and those who might conveniently "lose" one if it appeared on the job site.

Another case study is based on one of the authors' experience as the head of the construction planning department, in one of the leading Israeli construction companies, at the beginning of the previous decade. A computerized CPM plan, for a specific project was developed, together with the project manager and the superintendent, and then the output was brought to the site. After he received a negative answer to his question - "is the output able to hammer nails?" - he said, "put it anywhere you want, just don't bother me with it". This type of reaction was typical and portrayed hostility.

The third case study is the introduction of the partial automation of grading equipment using laser alignment system. The traditional method of grading requires skilled operators. It takes approximately eight years of training and practice to develop the highest level of expertise. The laser-aided grading technology provides assistance to the operator in controlling the blade to cut the soil. This system would require less skilled operator but would achieve similar or better results than the most experienced operator.

The contractor experienced many problems in the development of the system, which were technical. However, one nontechnical problem cited was the strong resistance from the experienced operators. Many of them considered the new technology a slap in the face and refused to use it. In fact, four of the top operators left the company to protest the new development. The system gained acceptance among the younger operators once the technical "bugs" were resolved and particularly after the apprentice operators achieved production rates of up to four times those of highly skilled operators.

Because many variables are involved in each of the studies, there is insufficient evidence to make any hard conclusions regarding project level resistance to the introduction of automation. However, both from the case studies and the surveys, there appear to be strong indications that construction automation can be expected to meet significant resistance from some project level employees.

5. STRATEGIES FOR RESISTANCE TO CHANGE REDUCTION

This section summarizes very briefly some of the main elements in common resistance to change strategies.

5.1. Education and communication

One of the most common ways to overcome resistance to change is to educate people about it beforehand. Communication of ideas helps people see the need for and the logic of a change. An education and communication program can be ideal when resistance is based on inadequate or inaccurate information and analysis, especially if the initiators need the resistors' help in implementing the change.

5.2. Participation and involvement

If the initiators involve the potential resistors in some aspect of the design and implementation of the change, they can often forestall resistance. With a participative change effort, the initiators listen to the people the change involves and use their advice. Some managers have controversial attitudes towards participation during change. Some feel that there should always be participation during change, while others feel this is virtually always a mistake. Both attitudes can create problems for a manager, because neither is very realistic.

Considerable research has demonstrated that, in general, participation leads to commitment, not merely compliance. In some instances, commitment is needed for the change to be a success. Nevertheless, the participation process does have its drawbacks. Not only can it lead to a poor solution if the process is not carefully managed, but also it can be enormously time-consuming. When the change must be made immediately, it can take simply too long to involve others.

5.3. Negotiation and Agreement

Another way to deal with resistance is to offer incentives to active or potential resistors. For instance, management could give a union a higher wage rate in return for a work rule change; it could increase an individual's pension benefits in return for an early retirement.

Negotiation is particularly appropriate when it is clear that someone with significant power to resist is going to lose as a result of a change. Negotiated agreements can be a relatively easy way to avoid major resistance, though sometimes expensive. Once a manager makes it clear that he will negotiate to avoid major resistance, he opens himself up to the possibility of blackmail.

5.4. Explicit and implicit coercion

Finally, managers often deal with resistance coercively. Here they essentially force people to accept a change by explicitly or implicitly threatening them, or by actually firing or transferring them. Using coercion is a risky process because inevitably people strongly resent forced change. But in situations where speed is essential and where the changes will not be popular, regardless of how they are introduced, coercion may be the managers' only option.

The above elements do not cover the whole spectrum of resistance reduction actions. Successful organizational change efforts are, in many cases, characterized by the skillful application of a number of these approaches, often in very different combinations. However, successful efforts share two characteristics: managers employ the approaches with a sensitivity to their strengths and limitations and appraise the situation realistically.

As mentioned before, the above elements, and others, need to be processed and adapted to a construction automation environment (stage three of the methodology).

6. CONCLUSION

Automation and robotics is receiving increasing attention as a means for solving some of the serious problems faced by the construction industry today. Successful application of automated systems into the construction environment requires to overcome some technical, economic, institutional, organizational, social and human barriers. The article deals with some aspects of the latter. It is shown that developing efficient robotic systems alone will not ensure successful implementation, due to expected resistance.

The article reviews potential sources of resistance (who might resist and for what reasons?), and reviews some resistance reduction strategies, used by the manufacturing industry.

ACKNOWLEDGEMENT

The authors which to thank Dr. W. DeLuca for all his help towards the successful completion of the thesis, which is the basis of this article.

REFERENCES

1. Arditi, D. (1990). "The Future of Automation and Robotics in Construction Activities". Proceedings of the 7th International Symposium on Automation and Robotics in Construction, 5-7 June, Bristol, England, pp. 447-454.

2. Argote, L. and Goodman, P.S. (1986). "Investigating the Implementation of Robotics". In Davis, D. (ed.) Managing Technological Innovation: Organizational Strategies for Implementing Advanced Manufacturing Technologies.

3. Argote, L. et al (1983). "The Human Side of Robotics: How Workers React to a Robot". Sloan Management Review, Vol. 24, pp. 31-41.

4. Chao, G.T. and Kozlowski, S.W. (1986). "Employee Perceptions on the Implementation of Robotics Manufacturing Technology". Journal of Applied Psychology, Vol. 71, pp. 70-76.

5. Fenves, S. (1990). The Potentials of Computer-Based Technologies in Civil Engineering. The Twenty-Ninth henry M. Shaw Lecture in Civil Engineering, North Carolina State University.

6. Contractors Association Special Committee of Automation in Construction. Research of Automation in Construction: Survey of Professional Contractors. Tokyo, Japan, 1989 (in Japanese - selected sections translated).

7. Kelly, P. (1990). Development of a Strategy for Introducing On-Site Construction Automation: The Human Aspects. Thesis presented to North Carolina State University in partial fulfillment of the requirements for the degree of M.Sc.

8. Majchrzak, A. (1988). The Human Side of Factory Automation. Jossey-Bass Publishers, San Francisco.

9. Manufacturing Studies Board (1986). Human Resource Practices for Implementing Advanced Manufacturing Technology. Committee on the Effective Implementation of Advanced Manufacturing Technology, National Research Council, National Academy of Sciences. National Academy Press, Washington, D.C.

10. Navon, R. and Demsetz, L. (1991). "Survey and Further Issues in Construction Automation Education". Proceedings of the 8th International Symposium on Automation and Robotics in Construction. Stuttgart, Germany, pp. 327–332.

11. Neil, C., Solomonsson, G. and Sharpe, R. (1991). "The Short-Term Social Implications for Construction Workers of Introducing Robotics onto Australian Building Sites". Proceedings of the 8th International Symposium on Automation and robotics in Construction. Stuttgart, Germany, pp. 317–326.

12. Oglesby, C. (1989). Productivity Improvement in Construction. McGraw–Hill, New York.

13. Paulson, B.C. (1986). Anticipating Technology's Impact on Construction. North Carolina State University.

14. Paulson, B.C. et al (1988). "Construction Division Input to ASCE Conference on Civil Engineering in the 21st Century". Journal of Professional Issues in Engineering, Vol. 114, No. 3, pp. 317–26.

15. Tatum, C.B. (1989). "Design and Construction Automation: Competetive Advantages and Management Challenges". Proceedings of the 6th International Symposium on Automatiofn and Robotics in Construction, June 6–8, San Francisco, CA., pp. 332–339.

16. Tatum, C.B. and Funke, A.T. (1988b). "Partially automated grading: construction process innovation". Journal of Construction Engineering and Management, Vol. 114, pp. 19–35.

17. Tavakoli, A. and Riachi, R. (1990). "CPM use in ENR Top 400 Contractors". Journal of Management and Engineering, Vol. 6, No. 3, pp. 41–51.

18. Warszawski, A. (1989). Industrialization and Robotics in Building. Harper and Row, New York, NY.

19. Warszawski, A. (1991). "Implementation of Research in Building". Proceedings of the 2nd Rinker International Conference of Building Construction, Gainesville, Florida, USA, April 1991.

20. Warszawski, A. and Sangrey, D.A. (1985). "Robotics in Building Construction". Journal of Construction Engineering and Management, Vol. 111, pp. 260, 280.

For Workers:

1. Fear of Unknown Changes In and/or Desire Not to Lose:

   - job or employment,
   - extrinsic rewards – pay, bonuses, promotion opportunities,
   - intrinsic rewards – skills, pride in work, job satisfaction, autonomy, challenge, status,
   - social and interpersonal relationships at work.

2. Fear of Inability to Handle:

   - requirements of training/restraining,
   - new work methods and skills required for new technology.

For Lower and Middle Level Managers

1. Fear of Unknown Changes In and/or Desire Not to Lose:

   - control/power,
   - authority,
   - competence,
   - status-quo,
   - career/promotion opportunities.

2. Fear of Inability to Handle:
   - new ways of doing business,
   - learning to use new tools or technology.

For Both Workers and Managers

3. Lack of Any Perceived Personal Benefit, or the Perception that the Negatives Outweigh the Postitives.

4. Poor Implementation Efforts

   - inadequate planning,
   - inadequate user involvement,
   - inadequate training.

5. Poor Labor-Management Relations.

Figure 1: Sources of Resistance to the Introduction of Automation in Manufacturing.