Application of Artificial Intelligence in Industrial Automation & Control Systems

There has been much concern lately that Artificial Intelligence may introduce new risks to society and might even result in the replacement of mankind by robots. Although this may be possible in the far future, after 50 years of applying increasingly sophisticated automation in industrial facilities I believe that these risks are manageable.

It is true, however, that the recent accelerating rate of AI technology development and application justifies careful consideration. This article therefore addresses some of these risks along with measures that have addressed similar risks in the past.

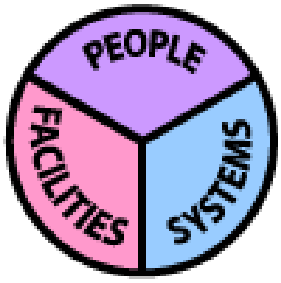
These concerns are nothing new and have been effectively dealt with since the PERA principles that were defined many decades ago. To provide a consistent structure for this review I have used the original PERA principles.

Eventually, there will not be enough people to deal with upsets or emergencies.

Issues

Automation is the process of reducing the number of people in the Enterprise compared to the facilities and systems they must manage. As AI becomes increasingly capable, there is a risk that this may result in inadequate staff to deal with emergency situations such as upsets or emergencies.

Resolutions: Over decades, dramatic reductions in staffing levels have proven manageable. It must be noted, however, that this process has been very gradual allowing evolution of operating procedures and improved training. Development of new communication technology has also improved remote technical support, and centralized Network Operations Centers (NOC) have proven feasible.

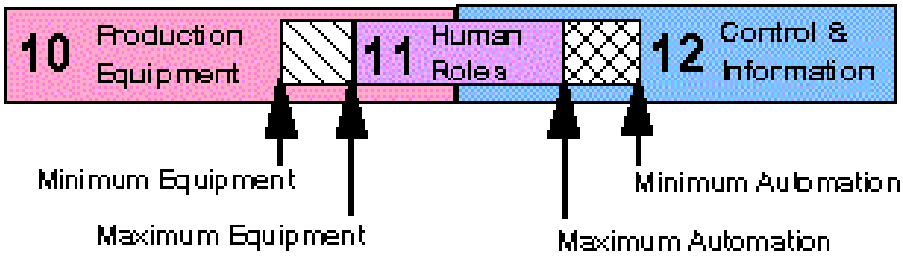


The accelerating rate of AI application does however increase risks. This risk may be dealt with using Business Process Modelling (BPM) and Improved enterprise design. The PERA methodology is designed to improve enterprise architecture design and PERA master planning emphasizes human roles and organizational design.

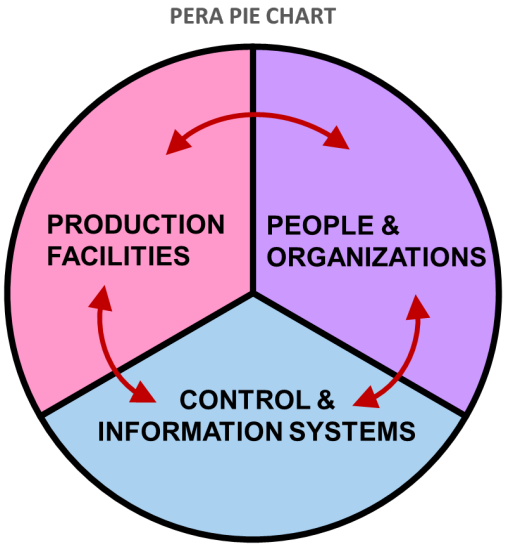
Changes in the "Line of Automation" may create risks

There are actually two "Lines of Automation each of which may be set anywhere between Maximum and Minimum:

- Replacing people with Equipment (conveyors, packaging equipment or other automated equipment), and
- Replacing people with control and & information systems.



Where these lines of automation are established is important because most operating problems and errors occur at the human interfaces.



It has even been suggested by companies like Neuralink that physical connections between human brains and control and information systems will be necessary in the future.

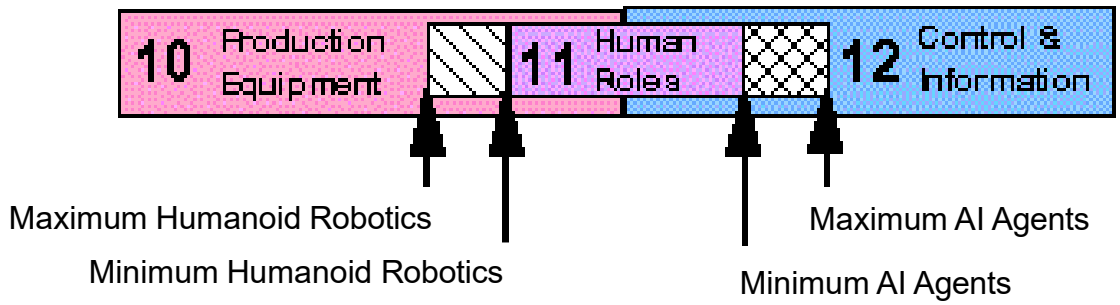
Level of Automation may be Different at Different Levels in the Enterprise Architecture

The chosen Line of Automation at IACS levels may be different than at MES or Office levels. This may be because of safety at lower levels, but the economic consequences may also be high for a production scheduling or quality control errors at the MES or

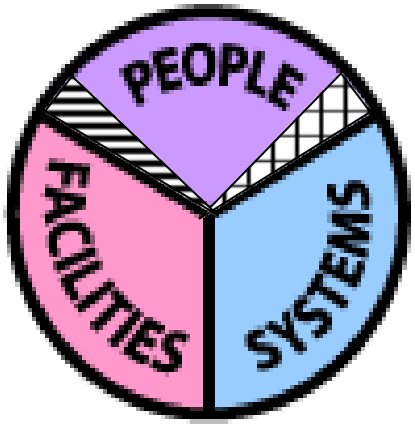
even corporate level. Whatever level of automation is chosen, it is important to apply this consistently across related control and information systems.

Artificial Intelligence Introduces new Human Interface Problems

After the line of automation is decided during enterprise design, and even after the enterprise is in operation, introduction of AI makes possible significant changes in the role of people. This can occur at any level in the Enterprise, but it can have particularly serious consequences in industrial Automation & Control Systems,



This introduces new interfaces for human operators. Traditional human interfaces to Control and Information systems and to plant equipment have been evolved over many years and are thoroughly understood and well documented in the plant design. However, .the Reliability, Response, Resolution and Repairability of these new AI interfaces may not be known and may even be unpredictable.



The new AI interfaces may even be faster and better than a human. For example, an AI agent monitoring network traffic might detect and even deal with an intrusion more quickly than a human. However, if the operator does not understand what is happening, the result will be confusion and the operator will no longer be in control.

Ultimately, the human role may be (almost) completely replaced. Anthropomorphic robots can walk out and open or close valves, or move a drum of lubricants from storage and connect it to a compressor. Control and optimization systems are already in widespread use that are operating at a level that most operators cannot replicate. It is quite reasonable to expect that planned facilities to produce rocket fuel on the moon will be completely “unmanned”.

There is of course the risk that AI will “take over” and humans will be replaced 😉

Artificial Intelligence is just the latest in a series of increasingly sophisticated matrix mathematical techniques.

In the early 1970’s, LP optimization of refinery schedules
Use of large linear matrices to maximize an objective function (usually profit in $)

In the late 1970’s Non-Linear Optimization allowed more sophisticated (sectionally linearized) relationships to maximize profit from inherently non linear processes (like gasoline blending).
Issues and resolutions:

In the 1980s Box and Hunter Fractional Factorial design
Attempted to find best operating parameters by making small but statistically significant disturbances in controllable independent parameters and observing the effect on dependent parameters (process unit performance).
Issues and resolutions: The number of independent parameters quickly resulted in experimental programs that were not practical on process plants where deliberately non optimal parameter settings could cost millions of dollars per day.
Issues and resolutions:

In the 1990s Expert Systems
A large number of “mathematical rules” used by the best operator(s) to control their process unit were captured. A matrix mathematical algorithm then used real-time process conditions as inputs to find a “best solution” for process performance by combined by a matrix mathematical technique to
Issues and resolutions:

By 2000 model based control
Issues and resolutions:

By 2010 Digital Twin models are used to check operation changes
Issues and resolutions:

In 2020 we began to see AI cyber attack and countervailing defence systems
Issues and resolutions:

Asimov’s early “laws of robotics” are already obsolete
Issues and resolutions:

Elon Musk contends the most fundamental law is that “AI must not lie” or we will not be able to control it after it exceeds human intelligence.
Issues and resolutions:

At the very least we must design “watcher “ applications (that can see and report anything unusual). These are similar to existing alarm procedures that have been used with control systems for decades (since process optimization and operator expert

systems).
Issues and resolutions:

There are already “NOC and SOC installations that provide overview of many facilities and even provide response to emergencies.
Issues and resolutions:

Principle 6 - We need a classification system for AI applications

So we can find common characteristics of AI applications that we can use to:

- establish “guard rails” for the risks that each AI technique entails.

Some of these include:

- Each of the Optimization techniques described above may be amenable to Neural Net solutions or enhancements.
- LLM
- Text to image
- Speech to Text
- Translation (voice to voice, voice to text and text to voice)

Key Messages

Accelerating rates of AI adoption will require more careful design and modelling of human roles.

There is a need for a classification system for AI systems, particularly where they involve control of critical infrastructure

The Line of Automation must be a carefully considered and documented choice at all architectural levels.

The Line of Automation must be established during the appropriate enterprise design phase and documented along with other “Engineering Deliverables”.

There can be serious consequences if control is taken from the Plant Operator. Operating procedures have evolved over many years to ensure that operators can always intervene to maintain safe operation.

At the very least, AI agents or humanoid robots must inform the operator “after the fact” of any initiative that it has taken and the reasons for its actions.

It has been suggested that truthfulness must be the first law of AI. (Elon Musk). Even more than being truthful, perhaps what is also needed is an assessment of the probability of the AI agent’s answer being correct.