> **IoT systems should be designed so that they deliver more than raw and semi-processed data, information and alarms to appear on a dash board**

Situational awareness brought to you by IoT

Increased technology, such as the Internet of Things (IoT), does not increase situation awareness itself. However, technology will help reduce the impact of the situational awareness **barriers** and improve decision making when used as it was intended [1]. We can become mesmerized by technology that can be held in our hands to communicate, learn, and entertain to the point of distraction, and miss altogether the context that the medium is trying to convey.

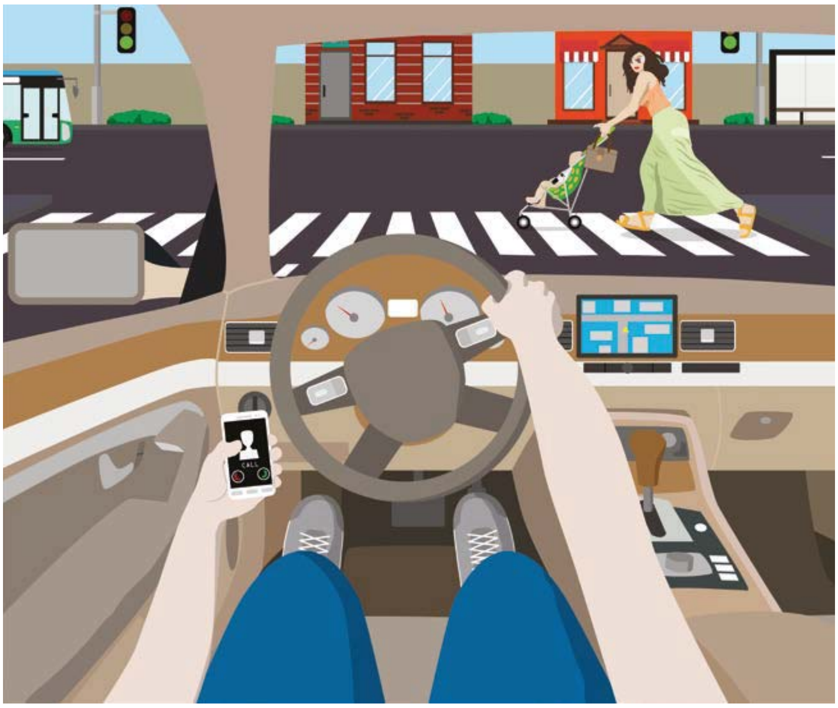
With this in mind, and from my experience, comes real life observations of good intentions gone wrong at various stages of IoT. This is not an exhaustive list, but more commonly offering situations of doing before thinking.

The absolute need for a foundational understanding

Many who believe the IoT is the ultimate problem solver, or panacea, must first understand what they have, or more importantly, need to make use of any technology. I refer to **data**, or more importantly, the **history** of an asset and its importance to the task at hand.

"History offers something all together different from (scientific) rules, namely ***insight****".*

The true function of historical insight is 'to inform (people) about the present, insofar as the past, (it's apparent subject matter), is encapsulated in the present and (constitutes) a part of it not at once obvious to the untrained eye'.
**R.G. Collingwood, 1939*
Autobiography. [2]



After an asset owner has described the "why" (refer to my column in [4]) they want to proceed with an IoT implementation. The focus then must go to what history (data) they have regarding the chosen assets they want to include.

What data/information is available and what format is it in?

- Offline/Infrequent/Sparse

In other words, is it "sparse data"? Meaning, test results with long time intervals between tests. The data is obtained from laboratory testing of fluids or electrical tests performed when a unit is out of service.

OR

- Online

Is data available from sensors and/or monitoring systems recorded with a unit in service, and is that data accessible remotely?

The difference between the two will offer a different insight to the units' behaviour and will greatly influence the results.

If one has only offline data, then all of those "snapshots in time" need to have further context surrounding the data, such as weather conditions, reason for testing, recent loading on the unit, and any obvious visual findings. These findings and more should be recorded and in the record.

If the data available is from sensors and/or monitoring systems, and is archived in a database that is accessible to the IoT, it is important to address what is available (parameters, tag names etc.) and determine the following before accepting it into an IoT process. Questions include, but are not limited to:

- Is the record **correct** and does it look **logical**? Units of measure and certain numbers such as dates or the relative saturation of water in oil cannot be negative. However, expected temperatures measured can be negative.
- Is the record **complete**, meaning no gaps in the time series data archived?
- Is it **consistent** in terms of expected repeatability of the measured values? Are the values within the normal bounds of the measured parameter?
- **Context**, YES or NO? If the unit is de-energized, are the expected signals for voltage, current, and bushing monitors at zero? What discreet notes are written within these test reports? Many times, numbers by themselves, do not always tell the real story. I would refer the reader to my last column in Transformers Magazine [3].

The objective behind this effort is to understand and gain insight of the asset and to set expectations of the asset owner with respect to implementation of IoT. For example, too many times, I have discovered with the asset owner, the available signals from sensors may include **only** items such as top oil temperature, loading, and little else. There may be a lot of sparse data, which may or may not be useful. Without additional sensors/monitors deployed on the selected assets, many failure modes will escape detection and may result in forced outages or worse.

IoT systems should provide a notice of an anomaly from the normal behaviour of the asset, identifying not only the asset involved but also the component(s) involved

IoT plug and play?

I have yet to see a true "plug and play" solution offered, let alone implemented, without support from experts who have "been there and done that". I have often found that some organisations who see IoT as the panacea, and determine that this is what can solve all their issues, just jump into it without considering all that is necessary. An experienced IoT provider must have the knowledge, including domain knowledge of the type of asset, communications within the station, back office IT infrastructure

and resources for the solution that will meet the objectives detailed in answers to the questions, **why**, **who**, **what**, **where**, and **when**. [4]

> **IoT systems should advise what the urgency of the response required is and suggest next steps to take such as additional testing or removing the asset from service**

There are SIX key areas where a program has failed to meet objectives:

A. Adoption failure:
If the key team members cannot thoroughly express the IoT system and how best to use it with the benefits that can be accrued by its implementation, then it will never have the necessary support from the stakeholders. All possible stakeholders including departments such as HR need to be a part of the team to ensure success.

B. Design and installation failure:
To avoid this critical aspect, the expert needs to include the scope of work expected of them. This usually involves a site survey, review of available drawings, existing cabling available, and discussion with technicians on site who have worked on these assets in the past. This last item has provided the experts with a deeper insight than a lot of the paperwork may reveal. Last is the red-line of drawings and sign-off of the planned work on site.

C. Supervision of installations and end to end commissioning:
The company owning the assets may not have the resources or

IoT systems should be utilized to identify candidates for urgent minor repairs on site, major repairs off-site, refurbishment or the tool to assist asset managers to understand weak units that should be replaced

knowledge necessary to carry out all the engineering, installation and commissioning of the systems, communications locally and remotely, or the skill sets necessary for set up and start-up of the software systems, including the domain knowledge, to enable the intelligence behind the machine learning processes. The machine learning process leans heavily on **history** and behaviour commonly known as **insight** of the asset.

D. Prepare for change and implement a change management program:
Change is constant now and always in the future. Many current employees will be reluctant to change, especially if the technology (sensors and systems) are new to them and "untried". One of the necessary actions is early training of those who will be affected by the innovative technologies. By that I mean deep training including hands on installation training and case studies of how others who have followed this path have benefited. What reliable results look like and what bad results look like.

E. Lack of necessary collaboration:
This is probably one of the most interesting and intense aspects of implementation. For example, different departments within a utility have their own set of functions and priorities. The team members and the experts who have walked this bridge before can offer and demonstrate what the expected outcomes of this system would be to communicate the common objectives of the different departments. It is never obvious, until different parties come together to brainstorm, that there will be a benefit to their department and the company.

F. Lack of management support, organization and funding:
Support from the 'C' level in all departments or functions is crucial! Not only in developing the business plan, but also with determining, in detail, expected functions, construction, installation implementation of the procedures and systems to be deployed. The initial capital costs are one thing, but the continuous financial, training, and human resources including change management mentioned above are required now and in the future. Without these key planning and support functions, the program will fail.

Expectations

The implementation of IoT for substations should be designed so that:

1. These systems deliver more than raw and semi-processed data, information and alarms to appear on a dash board. It should provide the owner with a notice of an anomaly from the normal behaviour of the asset. It should send this notification of the "out of control" situation to identify not only the asset subsystem involved but also the component(s) involved. At the same time, it should advise what the urgency of the response required is and suggest next steps to take such as additional testing or removing the asset from service.
2. The IoT system should not be used as a protection system for the asset. Those schemes are already in place, such that in the event of a fast-occurring fault, the unit is removed from the network automatically. The IoT monitoring systems should be utilized to identify candidates for urgent minor repairs on site, major repairs off-site (in a repair facility), refurbishment or the tool to assist asset managers to understand 'weak units' that should be replaced.

Bibliography

[1] B.Sparling, T. MacArthur, *Reducing Risk, Increasing Situational and Operational Awareness on Substation Transformers*, Euro TechCon 2018 Proceedings

[2] N. Ferguson, Civilization, *The West and the Rest*, Penguin Press New York, 2011

[3] B. Sparling, *BIG DATA, where is it, and is it useful?*, Transformers Magazine, Vol. 5, Issue 4, October 2018, pp 56-61

[4] B. Sparling, *Future of Substation Monitoring: It is not just the software*, Transformers Magazine, Vol. 5, Issue 2, April 2018

Further Recommended Reading

A) CIGRE Technical Brochure 630, Guide on Transformer Intelligent Condition Monitoring (TICM) Systems, 2015

B) CIGRE, Guide for Condition Assessment of Power Transformers, planned publication Mid-2019, WG A2.49

Author

Brian D. Sparling, a Senior member of IEEE, is the Senior Technical Advisor with Dynamic Ratings Inc. Brian has over 20 years of experience in the field of power and distribution transformers. For the past 25 years, he has been involved in all aspects of monitoring, diagnostics and condition assessment of power transformers. He has authored and co-authored more than 27 technical papers on various topics dealing with monitoring and diagnostics of transformers. He has contributed to many guides and standards with the Canadian Electricity Association, IEEE Transformers Committee and the Cigré A2 Transformers Committee.