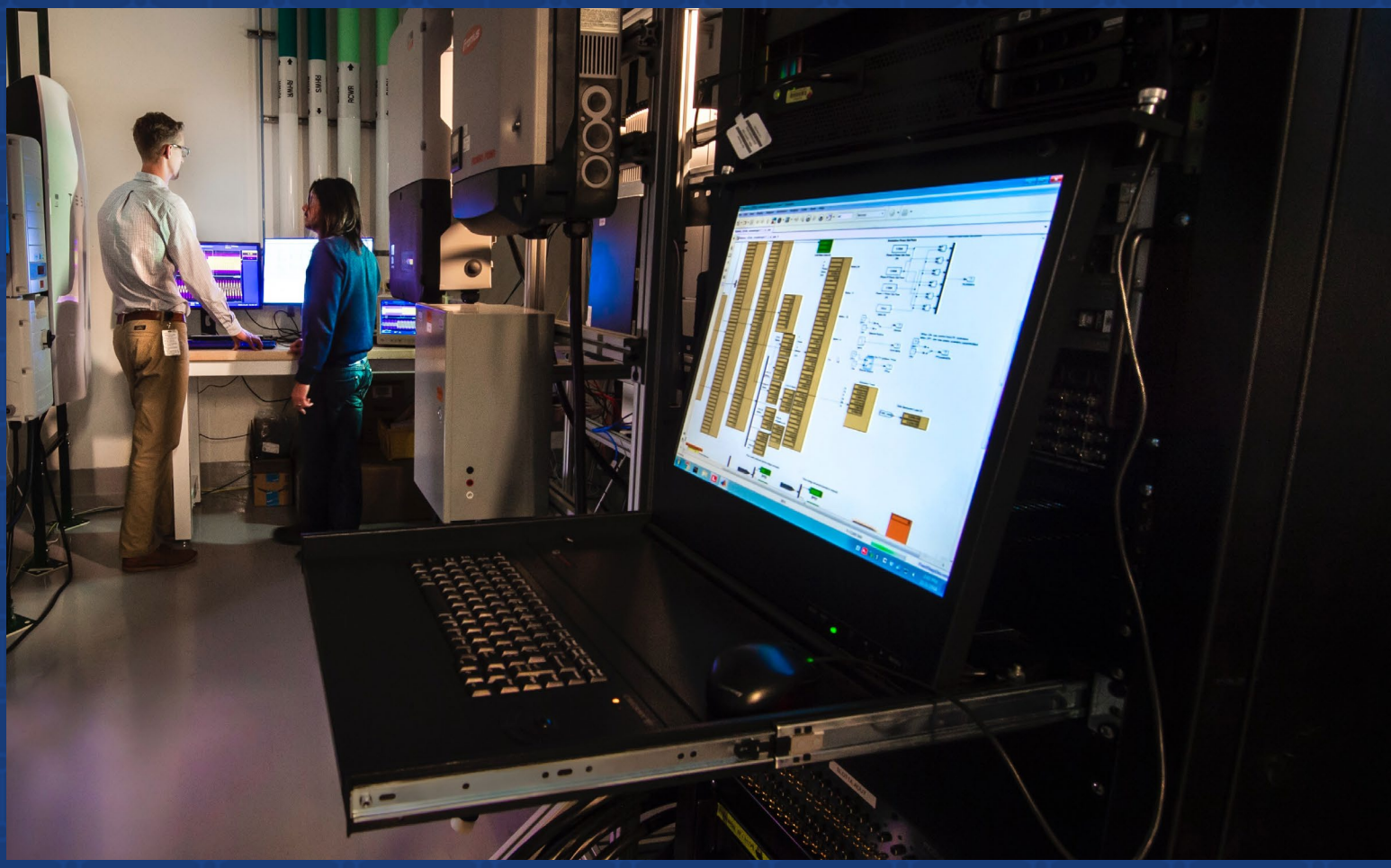
GRIFFIN

The Journey to a Digital Factory Part I

From Levers & Spreadsheets to Automation & Digitization



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Introduction

This whitepaper will discuss the attributes of a digital factory as well as key factors and steps for users either in the process of creating a digital factory (enterprise) or as part of the vision statement for productivity improvements. Various surveys (e.g. 2022 State of Manufacturing Report) show over 90% of manufacturing and process industries are investing in digital factories. This can be a daunting task as many of the operations and engineering personnel assigned to the task are experts in their field of production and not necessarily IT/OT type of experts. With a huge market potential, there are hundreds if not thousands of suppliers clamoring to help these experts, but this also creates a large amount of confusion on how to proceed and concerns about proceeding down paths that may be dead ends, have high maintenance costs, captive vendor syndrome issues and/or just do not meet the intended goals.

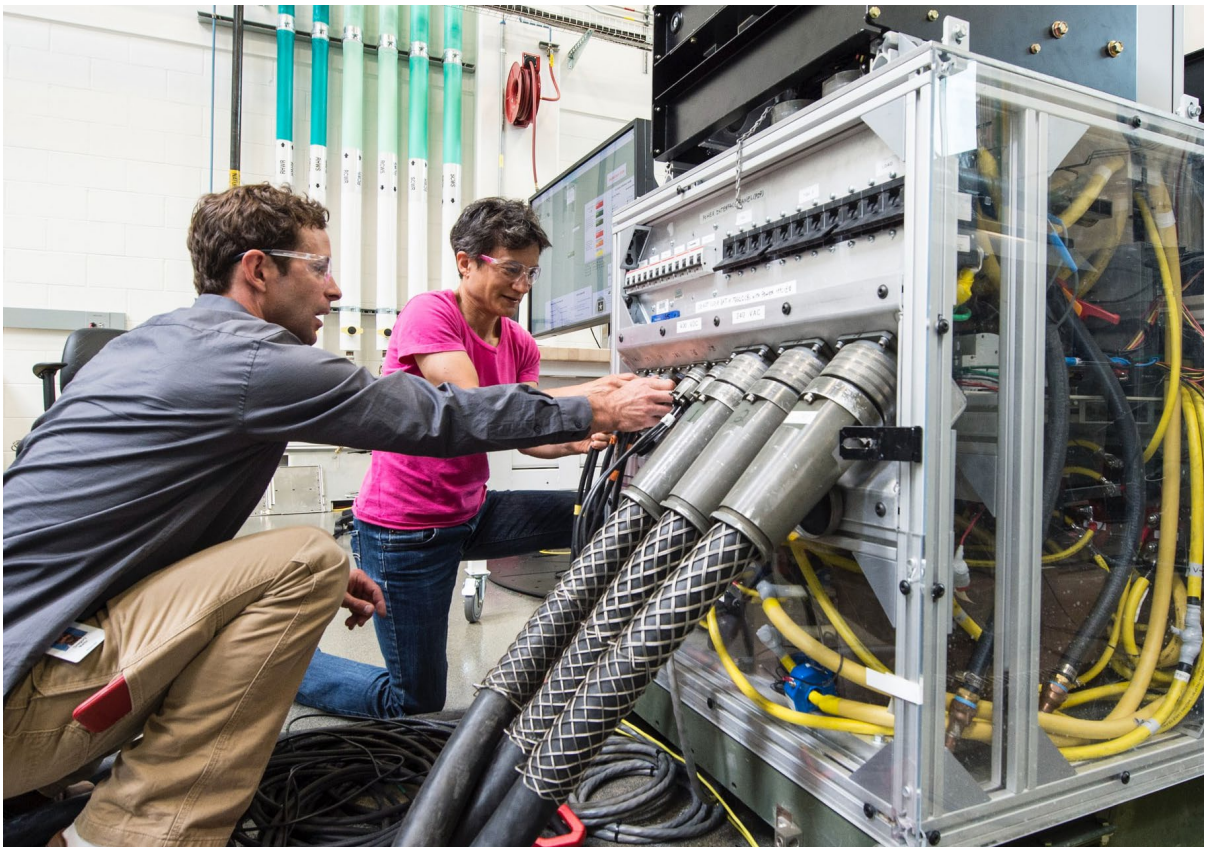
This series of white papers will discuss many of these decision points and key facets of successful projects. Our next white papers will go into more detail providing links for examples and guides to ease one along the journey.

Background

On the surface, the concept of a factory is simple: raw materials go in and a finished product of greater value to consumers comes out. As one looks at the factory more closely, it quickly becomes obvious that this represents a major achievement of humankind, involving multiple complexities and intertwined systems and objectives, each ebbing and flowing with its environment and surrounding systems. Any one factory is a combination of multiple processes and sub-processes, each representing its own set of challenges and measurements, providing numerous data points and tasks to be completed to move to the next step. Each step and process within a factory is contingent on the state of the preceding steps, as well as those following, and it's incredible that factories work as quickly and efficiently as they do, given the multitude of areas and opportunities for something to go wrong, any of which would immediately affect the factory as a whole. Added to this complexity is the need to optimize many aspects either for environmental concerns, changing customer demands, price of inputs, and other changing factors, which in turn leads to an increasing need for agile and automated manufacturing analytics.

In the age of digitization and big data, the "digital factory" appears more and more often as the goal to strive toward ultimate production efficiency and quality. Again, the surface-level concept seems simple: represent what's going on in the factory in the digital world on a computer screen. But similarly, transferring all of those processes and sub-processes, with their





complexities and intertwined operations and objectives into a digital state can seem nearly impossible. Countless factory managers, engineers, executives, and owners have recognized the potential of having a “digital factory” only to become overwhelmed with the daunting task of digitization EVERYTHING within the factory, and have given up, or at least hit an extended pause, because of a lack of resources and little realizable or visible return. Truth be told, many of those who approached the task in this manner made the right choice: they weren’t going to benefit from the digital factory enough to warrant all of their effort and capital.

There is a better way, and one that ANYBODY can accomplish, regardless of the complexity of the factory and system. The most attractive feature of the approach described is it is designed to be accomplished at a very low cost in time and money. With the right tools, there is less demand for IT/OT support and a good set of SW tools allowing rapid prototyping and implementation flexibility empowering the experts.

The two keys to this better way are 1) the incremental mindset, and 2) the incremental platform.

The Incremental Mindset

> The journey of a thousand miles begins with a single step"
>
> Lao Tzu

Referring back to Lao Tzu's famous proverb, anybody approaching the digital factory transformation must recognize that it is a tremendous journey, but they simply need to take it step by step and it can be accomplished. One of the biggest barriers to any type of journey of this size is the inertia created by focusing too much on where the journey ends. While it is important to understand where your enterprise wants to be, it is best to prepare for the many challenges and opportunities which arise, and move toward them to bring them into a manageable focus.

Going from manually repeating tasks with disparate information sources to deploying an AI system of automation is simply impractical to do all at once. It is important that the transformation process be carried out in discrete (i.e. small problem set), manageable, incremental steps.

The process will be iterative but the below description provides a summary of the main steps involved in creating a digital factory. Our next papers on this digital roadmap will go into more detail and present examples of the challenges and solutions which help guide the process.

A high-level view of the steps to create a digital factory

This can take a couple of different forms. One is to identify a common problem in the process which consistently requires manual intervention, often under the guidance of engineering. Perhaps it is an issue to continuously "run the numbers" in a report to catch problems before they occur. More generally, it may be a key KPI identified by management that is not readily available to operations to monitor progress or sufficient to understand all the variables affecting that goal.

Gather the data in a single database

A common problem encountered with this first step is organizing the data into a single database where manipulating and displaying the data is possible. For example, an operator makes adjustments based on his experience looking at key parameters he has learned through the years, yet engineering may be looking at different data and then needing to convey this to operations. Another example is an engineer generating reports in Excel so as to merge disparate data sources for analysis.

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In the next white paper, we will go into some of the pros and cons of architecture for the data network, including items such as cloud versus in-house servers, types of data storage, and issues of firewalls and cyber-security along with providing an example of compiling this data and then presenting the information on a dashboard and in a companion .pdf report.

No matter the selected architecture of your solutions, this step will require identifying the sources of the data. Questions such as

- Is the data currently available via a standard data link?

If yes, what are the constraints on the data link for a number of points, timing, and whether changes will be needed to the source system to allow data to be sent out?

Also, if in this step or a future step, do you envision sending data back, and will the data link support this?

- What is the form of the data being sent? Will it need conversion to a new data type? What will be the form of your new data source? Something simple like a .csv form is easily utilized by any number of applications but may become cumbersome if ultimately going “big data.” Fortunately, memory is cheap these days, and applications are better designed to handle large streams of data.

In the best case, your enterprise will already have moved to this centralized database.

Data conversion, Pre-processing

With the data centrally located, it generally will require some processing to turn into information desired by the end user. At this point, the focus is on:

1. What is the appropriate time period for the data? Instantaneous, hourly average, daily average?
2. How will bad data or missing data be handled?
3. What calculations need to be performed?

For purposes of this paper, this covers the process of converting data into information and not the more involved and nuanced area of data analytics. Data analytics (manufacturing analytics) will be treated separately as there are a lot of views on this subject that deserve a deeper dive. While important to know what data you need for the analytics, it is best to focus on first automating as much as possible the data clean-up, i.e. what rules are used to correct missing data, incorrect data, etc. Once this has been addressed, at least on a first-pass basis, it is easier to then work on what data analytics are going to be performed. Merging these steps creates inertia as an extraordinary amount of time can be spent on manual correction and sorting of data, leading to either incomplete analysis or at least more time pressures to perform the actual analysis.

Hence, one big advantage of this data processing or data pre-processing is the potential time savings for the personnel who are often doing data sorting, cleaning, and amalgamating manually in excel spreadsheets. Once this time is saved, more time becomes available to actually move on to the next incremental step.

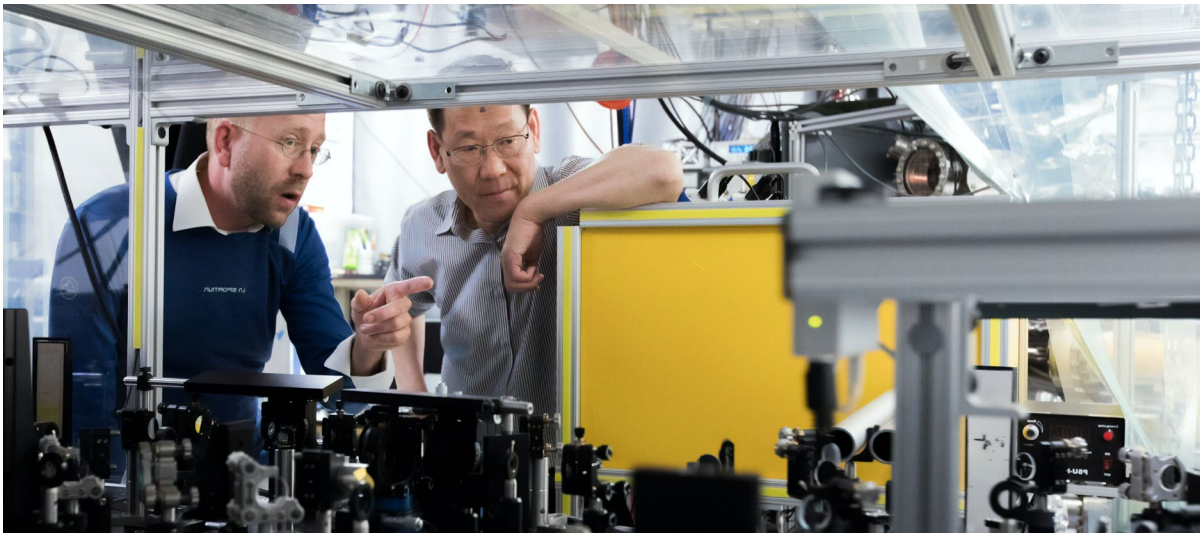
Dashboards and Reports

Once data has been cleansed, sorted, and pre-processed this should become readily available to the intended users. The basic questions here are:

1. Who will/should see this data?
2. Should this be on a computer screen as a dashboard? A web or printable report? In the daily email? Or some combination of the methods.

It is important in this step to focus on the high level readily visible, and not be swamped by intermediate data just because the data is now available. Drill-down dashboards and appendices in reports are good places to put the data supporting the key metrics being presented.

In our next whitepaper, we will discuss setting up a dashboard in a no-code, easy-to-start method. We will include keeping legacy type code, whether an existing dashboard is built in an open source environment like Grafana, or old analytical code using FORTRAN. Lastly, it will describe the customization of dashboards for 'power users' using a high-level language like python integrated into an easy-to-support no-code platform such as a Griffin Dashboard Toolkit. A free Griffin Dashboard Toolkit is available to follow along with the examples provided in that paper.



Manufacturing Data Analytics

Data analytics is a set of scientific techniques for analyzing data/information to make conclusions or at least gain insights into processes. Data analytics are important to identify key areas, such as process bottlenecks, key controllable data points, or poorly controlled variables. Once identified, these can then be improved by various methods (e.g. with a new optimized setpoint, or handled with a better control strategy). Additionally, the analytics may show where an underlying problem exists (without a straightforward solution) which can now be properly addressed leading to process improvements whether in business or manufacturing applications.

Data analytics has several types of analysis, including the major areas described below.:

1. Trends - A descriptive set of information tracking performance over time.

2. Diagnostics - An analysis of data to figure out why something happened.

3. Predictions - Analysis to evaluate the impacts of changes in the process which would affect the future trends for the process analyzed.

4. Prescriptive – Using the analysis to suggest courses of action.

5. Cognitive – Some analysts now add a fifth category as artificial intelligence (AI), machine learning, or deep learning techniques. This higher level of 'intelligence' provides methods for evaluating data for seeing higher dimensional patterns and allowing conclusions for more optimized prescriptive steps. In addition, cognitive steps can include a self-learning feedback loop allowing the data analytic software to learn essentially from its own sub-optimized performance and improve over time.

As a side note, the term optimized technically implies that the situation is ideal. In the real world, this means things are better than they were before. As we learn more, (i.e. get better data, better equipment, and better control), the process will get even better.

A future white paper will take a deeper dive into this subject and also discuss the boundary between offline analytics and conversion into real-time actionable results.

Models and Digital Twins

Models and Digital Twins are highly valued components of many process industries.

Models are a representation of a real process or product. They may be mathematical and simulated in software or could be scaled, physical models. In the digital factory, they would be software-based. Models are used extensively to design a process or product. They are a very

good method to evaluate trade-offs and identify key failure modes or cost areas to avoid. They can be used to compare current processes or product results to identify nonideal operations. Models are often limited by bad data, incomplete data, or data that is evaluated long after the process has been completed or the product was produced. Hence, models are now evolving into the next step.

Digital Twin has some key aspects which are a more evolved usage of a model. A digital twin, by necessity, will have a model of the process or object. This model must be adaptive and reflect existing data in the process/production operation and not just the ideal conditions or design basis. Lastly, digital twins should be dynamically updating and adjusting the model based on current (or at least near-current) data.

A digital twin will be running or associated with an actual production process or product. If not, it is just a model. The advantage is data is tested in real-time against expectations for the data. Adjustments are made to the model or the production process in response to deviations between the digital twin and the actual desired result. The goal is to either manually or automatically shift the process/product back to a situation that results in process adjustment bringing targets back toward expectations. In this regard, the best digital twins are efficient enough to run many simulations concurrently in real-time to achieve the best nudge to the process back to the desired goal.

As this is a high-value component of a digital factory, this whitepaper delves into this subject and provides a real-life example of how a digital twin is being utilized to save millions of dollars per year in fuel while eliminating millions of dollars more of waste.

Automation

Automation or the turning of all this data and information and analytic output into actionable data is the best possible outcome when a good digital factory is created. Alarms, notices, and reports are all important parts of a digital factory, given the time demand on operators, engineers, technicians, and management. While the need for manual intervention is normally a sub-optimized conclusion to a project, it may be a necessary step to provide recommendations to the operator until such time that hardware upgrades or control logic are made to permit the full automation of recommendations. It may take several iterations, test runs, and general confidence-building to get to this point of full automation. If successful, the result will be a much more proactive process resulting in cost saving or product quality improvement, but also a reduction of time expended by those involved. The latter is reducing or eliminating redundant or rote types of tasks. With process and production experts in increasingly short supply, allowing them to have more time on higher value problem solving is a key benefit ensuring the actionable part of the data is used in the most efficient manner. The bonus is the knowledge capture that occurs with the automation project.

Adivarent Control

A transitional area between control systems which are handling the primary control elements and safety aspects, and the operator making manual changes to the systems, is what we call Adivarent Control. This represents the intermediate layer between the DCS/PLC and the operators. It is designed to assist operators with feedback through dashboards and analytical tools and to assist the DCS/PLC by handling multi-dimensional and otherwise complex control options. Typically this Adivarent Control provides bias recommendations to fine-tune the DCS/PLC operating curves for a given operating condition. To learn more about Adivarent Control, please read the summer 2022 issue of Electric Energy Magazine article by Dr. Jake Tuttle, "Adivarent Control: The Real-Time Assistant Maximizing Systems and Operator Effectiveness and Capabilities".

The Incremental Platform

> "Making a plan without the right tools is like making spaghetti without a pot"
>
> Kris Hughes

Just as important as the mindset one must have to focus on incremental goals of a daunting task, is the need for a platform to enable the task to be reasonably completed.

Such a platform must be capable of supporting the integration and manipulation of information in a piecewise manner. When the new item is pursued or new customization is desired, it should be relatively easy to accomplish the task. It should not require what's already been developed to be completely redone but put on hold for months (awaiting vendor changes), require bidding every step of the way, new training, or other issues associated with closed vendor solutions and islands of automation.

A common mode limiting success in large automation projects is to have many islands of automation where distinct software and hardware packages are selected on how they fit a narrow application need without regard to the level of training required in the aggregate for all the different islands. This compounds when figuring out the long-term maintenance costs and staffing requirements to handle all the various vendors for service calls. This is a challenge even for businesses building a broad offering of products through acquisitions or internal groups, for purposes of offering a complete digital enterprise solution. A company like GE which is able to invest huge sums of money into GE digital struggles to integrate its acquisitions. This results in a bottom line that is undesirable given the amount of staff required to support all the initiatives and the lack of true integration.

A frequent statement with regard to digital transformation is that they will fail without a clear plan and goal. This should be clarified and extended to include making sure you have a sound foundation to build upon and that the plan and goals should be modifiable as you learn during the process. It is true you don't want to engage in building a digital factory just for the sake of saying you now have a modern facility, but when building up in an incremental fashion using flexible tools you are able to capture the opportunities for improvement discovered during the journey.

Depending on the company's business model, avoiding captive vendor syndrome, along with the associated loss of control over your own data, are items of which to be aware. In some cases, it makes sense to have your data, analysis, and structure of the feedback to operations and management handled by a single vendor as it may represent a specialized field with few experts or the end-user has chosen an out-source model to help keep internal costs down and more focused. However, most end-users prefer to have some ability to modify and understand the offerings and do want to be able to customize a 'package' solution to meet their particular needs. Also, very few end-users want to allow their data to become more valuable to the vendor who is mining end-user data for the vendor's benefit, while simultaneously not having access to that same data. In addition, if only one vendor can support the application, then pricing power shifts to the vendor with no guarantee the vendor will stay in the market segment or dedicate the resources to be best in class. The latter is more often a concern with large conglomerate businesses which have a bottom-line focus where business units need to meet a certain ROI.

Characteristics of a good Digital Platform

Doing some research on various vendors is an important step before embarking on the digital journey or continuing on with one which is running into major obstacles moving forward with a current project. Some of the questions to evaluate are:

1. If you invest in training on the platform, will you need to take training or have different people become experts in the various applications, learning new programming languages, quirks of operation, etc? A good platform would have a common basis where an expert on one side of the factory could assist someone on the other side when it comes to a 'programming' type question.

2. How far can the platform take you along the journey? If you buy top-notch dashboarding software, will you then need to investigate new software to optimize each piece of equipment? Does it have AI capability and the ability to incorporate models?

3. Does it have the ability to integrate into legacy code, whether it be an existing dashboard or something sophisticated like a large amount of FORTRAN code modeling heat flux through a metal?

4. Costs to support, including the dollar cost of annual vendor support and upgrades, plus the cost of your staff time to work with the vendor. Low-dollar cost maintenance is negated if you have to deal with 10 patches and 20 phone calls for one item that should have had a root cause fixed early on.

5. The openness of the solution. Do you know what is going on and if adjustments can be made by your team or is change completely at the mercy of the vendor and when they can get to it?

There are a lot of glamorous advertisements out there in the digital workspace these days. It is hard to sort the information and determine a path forward. The digitization marketplace is currently large and rapidly expanding. Many billions are being invested in new software and in marketing campaigns keeping this a dynamic and challenging but exciting area to be involved with. The potential to make the end user's life better by reducing time spent on tasks that can

be automated or tools which allow the end-user to more quickly diagnose and fix problems is very attractive. It is impossible to know where the journey would end in all its details, but the important thing is to be able to start the journey.

This paper has been our overview of the digital factory challenges and we will be following up with a more in-depth look at each topic. We will provide examples and some of the pros and cons of various aspects of projects as they might evolve.

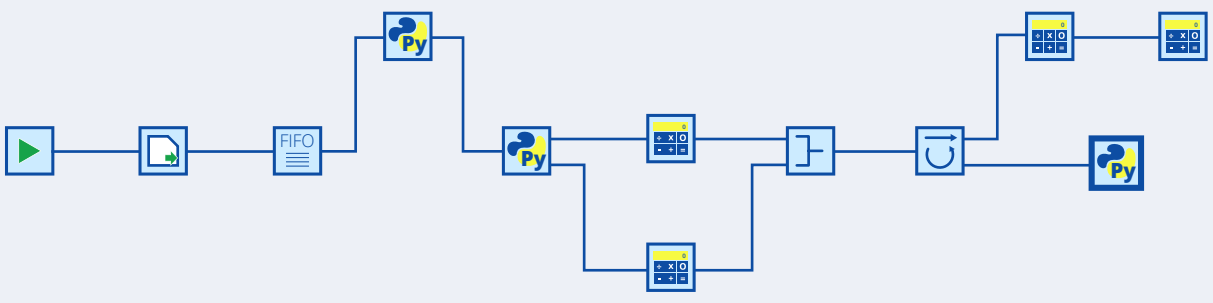
Griffin Dashboard Toolkit and Griffin AI Toolkit®

To facilitate our example, and allow you to work along should you so choose, we will be using the Griffin Open Systems, LLC family of platform tools for demonstrating various capabilities. We intend to release videos showing some of the steps described in the papers. When you submit your info to download the toolkit, you will also be enrolled in our newsletter to receive in-depth learnings and how-tos so you can best use the toolkit.

One advantage of the Griffin Dashboard Toolkit is the free version allows you to get started without a cost obligation other than your time and interest. As we progress to more advanced lessons demonstrating AI Tools and The Griffin AI Toolkit®, Griffin also offers a free trial period to ensure it is meeting your needs before committing.

We believe the Griffin family of Toolkits is an excellent incremental platform supporting the digital factory development process. This platform utilizes a visual programming environment with numerous components for system development, encouraging the incremental approach. As the critical information is identified and components pursued and integrated, the platform's working environment is simply modified by inserting a few more components or adding to existing ones.

An example of the Griffin AI Toolkit in action:



This whole process can be done with the system online, completely avoiding cumbersome shutdowns and recompiling of logic. This greatly expedites the incremental approach allowing rapid prototyping of concepts and ideas for improving the process or production method. With a common platform across many applications, ideas and techniques can be shared allowing synergy in creating solutions and lowering costs upfront and in long-term support.

Beyond data representation, the platform makes available many powerful AI algorithms, again through simple-to-configure components. Advanced neural networks and optimization processes can be deployed through a short sequence of clicks within the system, enabling powerful insights and actionable decisions to be made using the process information integrated during earlier steps. Through this, smart automation practices can be deployed with ease, all from a single digital platform and environment.

While we hope you will continue to use the Griffin Toolkits, the lessons are designed to demonstrate a process to incrementally create a digital factory and should have broad applicability no matter the course you choose.



Author Biographies

Dr. Jake Tuttle

Dr. Jake Tuttle holds a Ph.D. in Chemical Engineering from the U. of Utah and is the CTO and Managing Director of Taber International, LLC. Taber was established in 2006 to serve the process community with engineering expertise in an open and honest system. Since then, Taber has been a leader in the field of combustion optimization and advanced process control. Together with Griffin Open Systems, Taber focuses on creating next-generation software and optimization applications targeted to the utility industry using an open systems business model, allowing for the rapid inclusion of great ideas and practices, regardless of source.

Siva Alagarsamy

Siva Alagarsamy is a co-founder of Griffin Open Systems, LLC, and the Chief Software Architect for the Griffin Toolkit platforms. Griffin Open Systems provides an open architecture AI platform for industrial automation. The Griffin Toolkit TM provides an easy visual programming platform for end users to build process control and optimization applications using expert knowledge and machine learning. The Griffin platform is currently deployed controlling in real-time hundreds of process variables in power plants and steel mills for energy savings and environmental compliance solutions. Siva has a Bachelor in Computer Engineering from Manomaniam Sundaranar University.

Brad Radl

Brad Radl is a co-founder of Griffin Open Systems, LLC, and Managing Partner of Acuity Process Advantage, LLC. He founded Taber International, LLC in 2006 and is currently a senior consultant in business development. Brad is currently focused on the use of AI Tools in the area of process optimization for energy production and distribution, and supporting initiatives at Griffin and Taber for new techniques and approaches for the challenges encountered in the rapid digitization of the process industries. Brad received a B.S. in Nuclear Engineering from the U. of Illinois, and an MBA in Finance and Economics from Case Western Reserve University.

Get Started with Adivarent Control Today

For future white papers and notices when new videos for the digital factory become available, please register your name, company, and email on the contact us page of the Griffin Open Systems website. You may also request the free version of the Griffin Dashboard Toolkit.

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