

Anatomy of the Agile Fractal Grid Digital Twin Smart Grid

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Continuing the sequence of the Smart Grid whitepapers from the previous descriptions of the overall context of the 4-Tier Architecture of the Fractal Smart Grids^{1 2}, we now turn our attention to the Digital Twin, the method of mass customization deployment of the fractal patterns into production systems all over the world.

Now, there have arisen multiple definitions of what a Digital Twin is. Probably the best definitions are now coming from the Digital Twin Consortium (DTC) where the Agile Fractal Grid is now the co-chair for distributed energy resources in the natural resources section. This group is leading the efforts for definition through a “catalyst” like approach by incorporating the strategy of learning and optimization through actual lean development implementation into the real world.

DTC is *The Authority in Digital Twin*. It coalesces industry, government, and academia to drive consistency in vocabulary, architecture, security, and interoperability of digital twin technology. It advances the use of digital twin technology from aerospace to natural resources.

DTC is a global ecosystem of users who are accelerating the digital twin market and demonstrating the value of digital twin technology. Members set de facto technical guidelines and taxonomies, publish reference frameworks, develop requirements for new standards, and share use cases to maximize the benefits of digital twins.

DTC is open to any business, organization or entity with an interest in digital twins. Its global membership is committed to using digital twins throughout their operations and supply chains and capturing best practices and standards requirements for themselves and their clients.

¹ Whitepaper on the Anatomy of the Tier-2 Cluster Node

² Whitepaper on the Anatomy of the Tier-3 Regional Energy Operations Center

Through the collaborative culture within the DTC, the following strategies are played out:

- Influence the direction of digital twin technology development
- Become the focal point for digital twin thought leadership, trend analysis and industry perspective
- Create cross-industry digital twin reference architectures and definitions
- Promote, evolve and refine digital twin best practices and benefits
- Provide the definitive resource hub for digital twin producers and consumers
- Improve interoperability between digital twin technologies

Digital twin technology helps decision makers better understand how data collected from smart components can drive innovation and performance. DTC members from many industries are developing technical guidance, *reference implementations*, and setting industry guidelines to drive safer and more efficient deployments. These industries include:

- **Infrastructure** – Construction productivity is falling despite increased BIM adoption. Digital twins are poised to disrupt the construction and real estate development industries.
- **Natural Resources** – Natural resources related sectors, including oil & gas, mining, and *distributed energy resources* (DER) are becoming increasingly digital. Digital twins can be applied during the engineering, design, construction and deployment, and operations phases of the lifecycle to improve production, predict or detect problems, and improve safety.
- **Manufacturing** – Digital twins are being used to manage the performance, effectiveness, and quality of a manufacturer’s fixed assets such as manufacturing machines, lines, and plants. With digital twins, manufacturers can take a more strategic and holistic approach to asset management.
- **Aerospace & Defense** - McKinsey estimates that linking the physical and digital worlds could generate up to \$11.1 trillion a year in economic value

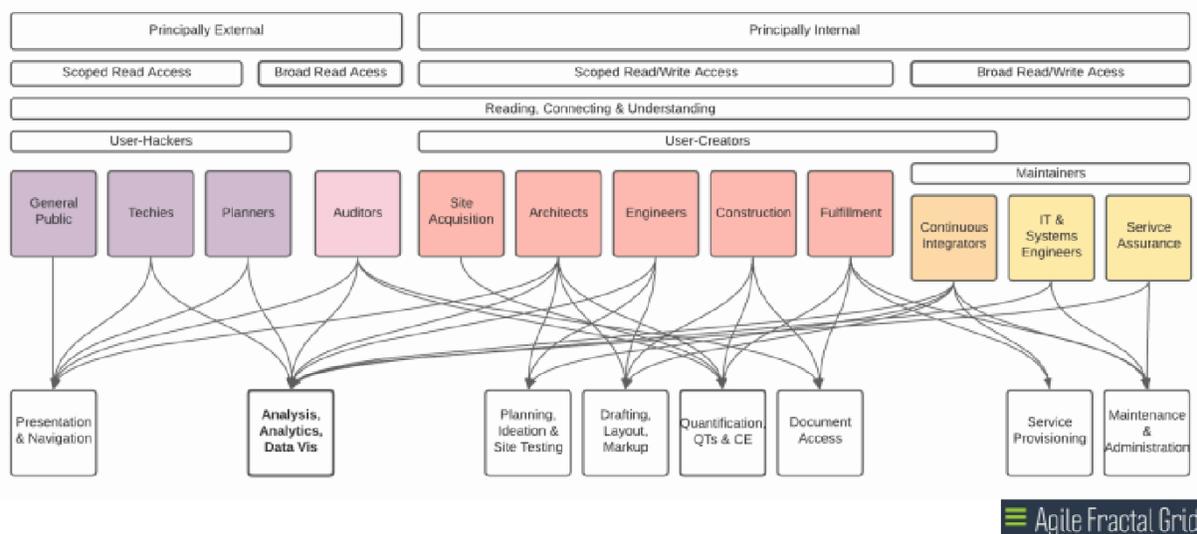
by 2025. The impact of digital twins on the aerospace and defense industry will be immense.

The Digital Twin reference project for the distributed energy resources domain is coming to life with the deployment of the 4-Tiered architecture by the Agile Fractal Grid at its integration and certification center at Babcock Ranch in Florida, a textbook example of smart city implementation.

The overall organization for the integration of the Digital Twin itself is being modeled on the designs and approaches offered by Cityzenith, another member of the TM Forum Catalyst for DBM III. Using this framework, there are many partnering tools and technologies that are used for the subsections like Bentley Systems and Revit by Autodesk. But it is the orchestration of the tools and the life cycle attention that makes the Digital Twin for the Agile Fractal Grid so comprehensive.

The following diagram is Cityzenith’s lean development first cut at the wider interests surrounding the Digital Twin for the lifecycle of the creation of the new infrastructure for the distributed grid deployment:

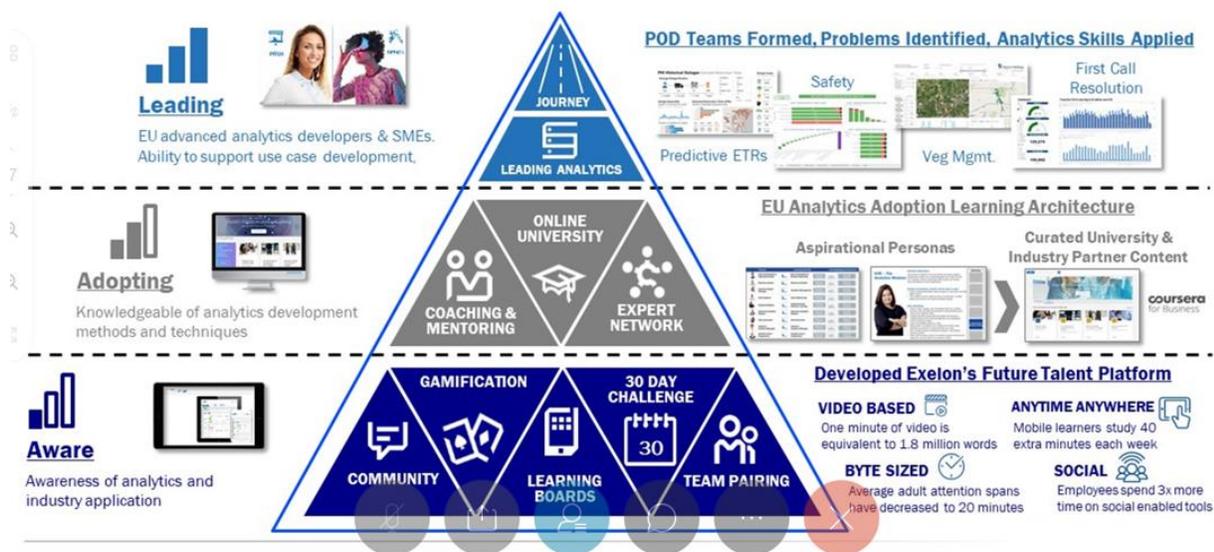
Use Cases & End User Fulfilment



In that the deployment of the decentralized fractal grid requires the participation of the people who live in a locale so that it best serves the needs of the specific situations there, the beginnings of the lifecycle actually starts with the steps to engagement of the local groups for the true requirements before proceeding to internal engineers, building groups, and production operations teams. This sequence is captured left to right across the reference lifecycle framework.

Now, focusing on the front end for a moment, we have the need to engage newcomers to the process by additional means other than fiat. This is where engagement becomes important, and the learning process must take hold before getting down to serious planning.

The methods for obtaining and propagating this engagement is illustrated by the Exelon process as illustrated in the following diagram.



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This is the pyramid of engagement as postulated by Exelon Energy, one of the AFG prospective partners. Working from the base to the top, a prospective collaborator must be discovered first, then those discovering the opportunity to design their own microgrid for their community must learn the basics of the

analytics, and finally those who have learned the techniques must solidify their skills by becoming mentors for those who follow so that the community of practice expands rapidly and organically in natural fractal fashion.

At the earliest stages, social networking is needed to gain awareness of the Digital Twin mechanism. In keeping with this need, we can use LinkedIn as the primary mechanism for enterprises and communities these days among other tools.

Next, we must reinforce the awareness with activity knowledge, know how, and inspiration to action. These essential aspects can be reinforced in people of any age who are young at heart through the subtle titillation inspired by a gamification in the learning process prior to actually entering the marketplace while people are so impressionable. There is a whole science as to why gamification is so effective in stirring the passions to get involved. There are actually whole companies dedicated to the study and nurturing of the uses of dopamine (video games), oxytocin (social), serotonin (food), and endorphins (sports) that are at work here. Not all at once, but as time rolls on, each of these stimulations for a different type of motivation will play a role in the experience we will be generating.

Games like City Skylines can be used to either design your own new city, or to come up with as exact a replica as possible of the real city that you live in for conceptualization. Through thoughtful stimulation, the first cut of virtually every city, town, village, and hamlet can be generated by the e-Sports enthusiasts as pointed out by the Tech-YOU-Topia inspirations in the Graceland University birthplace of Tech-YOU-Topia in Lamoni, Iowa. There are some lessons to be learned with this game approach relative to building one's own microgrids and smart cities. The results of the elaborate conceptual designs can be outputted and used as the starting points for the more detailed engineering designs by actual licensed practitioners next in the life cycle framework.

The "learning boards" can be based on the patterns of the communities of practice that have already been established for the Echo Project in New Mexico that are good models to emulate. Echo already has established over 600,000 practitioners around the world in some 154 countries. The AFG will be using these

techniques for building the Digital Twin at the integration and certification center down in Florida for the new smart city being deployed from the ground up near Accra capitol of Ghana in Africa.

AFG will lead a collaborating effort as a Champion of the TM Forum DBM III Catalyst program. These efforts will be the 30-day sprints using team pairing that AFG will use with all the pomp and circumstance related to recognition for the achievement – almost like a sporting event. (endorphins)

The next layer has to do with the propagation and upskilling in Tech-YOU-Topia style where we establish the Echo-style group learning stirred by the passions of doing something really good for others in league with likeminded others. This is meant to help one to achieve that Maslow Level 5 sensation of becoming that person that you always wanted to be.

All this would be followed by the entrance requirement that the dues you have to pay is that having mastered the art of skillful creation is that you are now obligated to play a role in passing this know how onto others so that they can do it for themselves, too. This is a level 6 sensation on the hierarchy of human needs. As a matter of passing thought, the Lion's Club has mastered this process for service and now has become the largest service organization in the world.

What is important for the up-front sequence is not just the recognition of how human beings work and the fulfillment of those needs. It is a matter of perfecting those skills with the smoothness, gracefulness, and strength of an Olympic athlete.

The back end of the Cityzenith lifecycle illustration is where the traditional infrastructure construction skills begin to kick in. However, this does not use the Henry Ford assembly line process. No, it is more akin to the Toyota flexible manufacturing process where every vehicle going down the Manufacturing 4.0 assemble line is a totally different type of vehicle: a Camry, a Corolla, and Tundra pickup... The same robot positions are used, but the just-in-time parts, and the AI-like rules adjust dynamically for each vehicle as it moves through the assembly and testing lifecycle. The same will be done with microgrid production, except

that it is quite doubtful that any two will look precisely the same as they are commissioned for operation and assume their role as the four tiers unfold.

As we graduate from the academic to the build it for real exercise, some additional tools come into play such as Autodesk Revit in the United States and Bentley Systems in Europe. However, the AFG Digital Twin can use both tools and for that matter can also include a myriad of other approaches at different stages of the lifecycle.

As we focus on actual fractal buildings like the CareCyte medical emergency care structures that can come together from first contact, to design of the mass-customized building, to fabrication, to construction, to provisioning with the actual medical instruments and grand opening in just 30 days... we would use Catia design software. This is an outgrowth of Boeing technologists that are using the same Digital Twin process that was used to produce the legendary Boeing 777 airliner.

Maxbytes who is another Champion in the DBM III Catalyst can be used in creating Industry 4.0 manufacturing facilities.

As is described elsewhere³, the Digital Twin is a simulator, not only used for design, but it actually becomes a part of the real production network for continuous integration and continuous deployment with elements of the Digital Twin actually in each component of the actual distributed system. For final, real world testing and for diagnosis purposes, the instrumentation is especially useful in both the development environment, but also for service assurance in the production network. Amazing, but true.

Perhaps the most difficult aspect of all in the Digital Twin Framework is the incompatibilities of the data stores used by the different vendors supplying engineering tools and BIM specifications. In the grand scheme of things, the fact that over time new technologies will be introduced all the time and they are all a little bit different. The Tower of Babel is alive and well here in the 21st Century. The only thing that saves us is that there is in fact one true reality... and that is the actual physical incarnation of the real network sitting right in front of us. All of the

³ DevSecOps whitepaper

assembly and integration of the parts (be they geospatial, physical, logical, or cognitive) needs to be done with an eye to a special ontological map that we use to facilitate a special “lens” for the dynamic translation of the syntax and semantics of the different configuration data that will be needed to tie everything together. This is where we will look to the Integrated Architectures Component Gallery and also the recent projects at Cornell University to help with this level of dynamic data integration.

To summarize then, the Digital Twin is a necessity for the large-scale rollout of the mass customized decentralization of the power grid which has delightfully been conceived and designed by the ordinary citizens who live in each of the locales. It must be done this way, because only they can define what happiness is in their communities. And if they have a large hand in doing it themselves, they will tend to defend their own creations to the death. Such is the way the world works.