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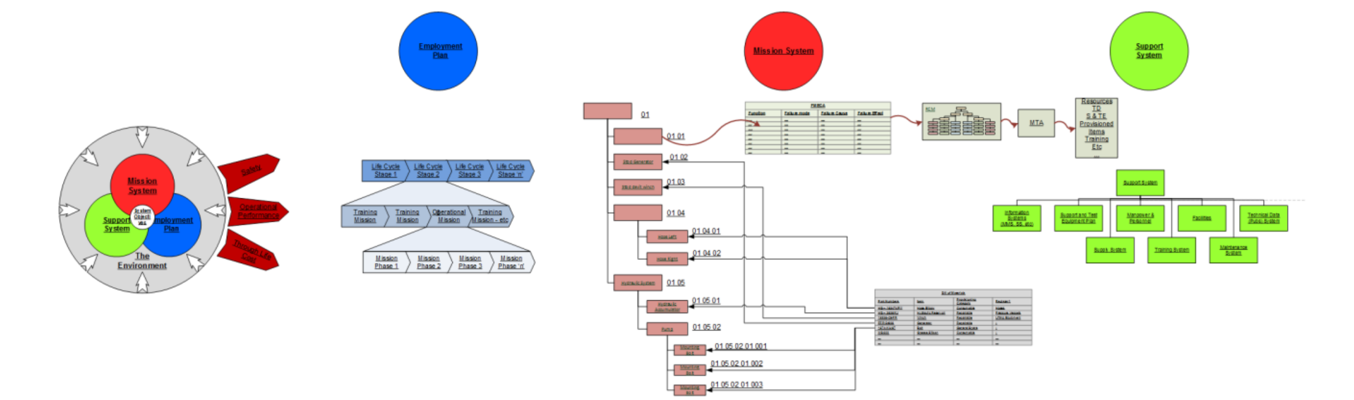
Support Engineering and the Digital Twin Concept

The Digital Twin concept is an attractive idea that has been around for about 15-16 years, but is gaining ground today, in part, due to the rise of the Internet of Things [IoT].
There are many articles and papers discussing the concept and they list many advantages of deploying Digital Twins, for example, they allow us to 'head off problems before they occur', 'plan for the future', 'prevent downtime', 'improve decision making' and they 'enable learning' amongst many other benefits…
But what is a Digital Twin and what have they to do with Support Engineering?



Towards the end of an article I wrote some time ago I mentioned that the Digital Twin concept could and should be, applied to Support Engineering, and I got a flea in my ear from one commentator for leaving this until late in the article and, by inference, for treating it so superficially.

I am attempting to rectify that fault in this article, but let me make clear from the outset that I am no expert in this field, so please regard this as a discussion piece and feel free to argue…

I will attempt to define what we mean by a Digital Twin and why, and how, I think the concept should be applied in the Support Engineering domain.

There are any number of definitions of a Digital Twin, but here is Wikipedia's definition:

Digital twins integrate artificial intelligence, machine learning and software analytics with data to create living digital simulation models that update and change as their physical counterparts change. A digital twin continuously learns and updates itself from multiple sources to represent its near real-time status, working condition or position. This learning system, learns from itself, using sensor data that conveys various aspects of its operating condition; from human experts, such as engineers with deep and relevant industry domain knowledge; from other similar machines; from other similar fleets of machines; and from the larger systems and environment in which it may be a part of. A digital twin also integrates historical data from past machine usage to factor into its digital model.

Which doesn't quite trip off the tongue, so let me put this in simpler terms, visualise a digital tool that contains a description of our "System of Interest" [SOI]; some form of database probably. Combine this with a means of predicting that system's behaviour, i.e. some form of simulation model. The data, and the architecture of both the database and the simulation, are constantly updated to reflect what is happening to our system, in the real world.

This combination will now allow us to determine, with improved fidelity, how our system is likely to behave in the future and it will therefore enable us to make better decisions; we can be proactive rather than reactive. It requires us to do this for each instance of a system, i.e. we need to do this for each individual vehicle, aircraft or engine, etc.

The advent of the Internet of Things [IoT], in particular, cheap, easily deployable, sensor technology and the use of mobile devices to support engineering activities, including making measurements and data gathering, is making it easier and cheaper to gather the relevant real world data.

So, taking this simplified view of the world of Digital Twins, what has this got to do with Support Engineering?

The first thing to understand is that, whilst most applications of the Digital Twin concept are applied to physical, engineered assets, and usually critical and expensive ones, (e.g. gas turbines) it can be applied to processes and systems, as my description above implies.

Ultimately, the Support Engineer is concerned with Operational Availability (as it contributes to Operational Capability) and Through Life Cost [TLC]. These are the function of the many complex interactions between the three elements of the "Total System", this is our System of Interest [SOI] comprised of the Mission System, the Support System and the Employment Plan. The concept of the Total System is a topic I have addressed in other articles and on many other occasions, so suffice to say here that it is blindingly obvious that we need a formal mechanism for defining each of these elements (something better than MS Word), some mechanism for capturing their 'architecture' and a detailed description. We also need to capture associated information, such as any associated Risks and Opportunities, Lessons Identified, Assumptions, Constraints, Stakeholders, Interface Definitions, Performance Indicators, etc. Aspire refer to these definitions as the Mission System Definition Environment [MSDE], the Support System Definition Environment [SSDE] and the Employment Plan Definition Environment [EPDE] respectively.

If we have such definition we can use them, amongst many other things, as the source of the data we need to populate our Availability and TLC models; we now have a good start point for creating a digital twin of the Total System.

[The basic concept here is not new, consider that the original LSA standards called for a "Use Study" which addressed the manner in which a system was to be operated and supported, a rough equivalent of the Support System and the Employment Plan concepts outlined above. They also called for a Baseline Comparison System to be developed and a Logistic Support Analysis Record [LSAR], this is, roughly, the equivalent of a Mission System Definition].

Suppose now that we give our MSDE some sophisticated configuration control capabilities, so that it can manage data associated with each individual, serial numbered, platform or piece of equipment. Suppose that we now collect data, facilitated by using RFID sensors, NFC tags, smart technical publications, IoT technologies, and the intelligent deployment of mobile devices, etc. That data can be associated with a fleet of platforms, with a type of technology and with a particular serial numbered equipment. Consider if we collected not just arising data (e.g. failure data) but also data defining the 'state' of an item (e.g. what is its remaining 'strength', where is it on the infamous P-F curve), its full service history and data defining the operating environment and the stresses affecting the equipment, not just at the point of failure but in the hours, weeks, and months prior to the present day?

If we combined this data with a prediction of the operating environment and the stresses it will experience in the near future, derived from operational / training plans, we will be able to predict the equipment's likely behaviour with greatly improved fidelity.

Consider also the well publicised problems with reliability metrics such as Meant Time Between Failure [MTBF]; exacerbated as fleet sizes and operating hours reduce and with them the 'sample size' for this statistical measure. Instead of using means, can collect actual arising data (in our digital twin) and use this as the basis of our input data to a modern sophisticated simulation tool?

Let us assume that the EPDE and the SSDE are also updated to reflect the real world, i.e. we enter actual manning data, rather than the 'establishment' figures; we can safely assume that this data is available, If we do this, we can then predict the impact of the Front Line Command's [FLC's] plans on the support workforce. We can predict how well the present workforce is able actually support operations and we can predict the impact on the establishment in the longer term (i.e. if the maintainers are over utilised what impact will this have on the turnover rates in the short, medium and long term?).

Other support resources can be treated in a similar fashion, imagine if the live spares situation was captured in the SSDE, when the simulations are run they can utilise this real data, if unserviceable repairables are accumulating in-theatre, due to a poorly thought through maintenance policy, then this can be taken into account when a simulation is run, and the impact on future operations will be immediately apparent (and “what ifs” can be run to determine the most appropriate fix).

Over time, we will have a better understanding of how different technologies behave in different environments, e.g. how do rotating machines behave in dry dusty conditions versus being operated in a warm saline environment, how do aluminium alloy structures behave in the same conditions, etc.

If the EPDE is maintained, we will have some understanding of the probable future operating environments. Mission durations, lengths of the Lines of Communication etc, and this will also form a key input into our simulation activities.

Finally, consider the situation when our system reaches the end of its useful life and a replacement system is being procured, the Digital Twin will now provide a rich source of “historical data”, a veritable “Pierian Spring”* of information and insights which will provide an invaluable foundation for any new project.

There is much more we could discuss with respect to a Support Solution Digital Twin (consider their relationship with feedback systems such as Date Reporting and Corrective Action Systems [DRACAS]), but I think that this gives a flavour and sufficient justification for pursuing the idea.

To summarise, we can create a “Digital Twin” of the Total System, it can start simply, and increased levels of sophistication can be applied over time. As the fidelity of the system increases, so will our ability to predict future behaviours with higher degrees of confidence, and even a small improvement in “predictability” will yield very significant opportunities to reduce cost whilst improving performance.

** At the risk of being patronising, the “Pierian Spring” is where the Muses drank and hence gained their great knowledge and wisdom; it was a sort of ancient Greek version of Wikipedia.*

Aspire: Aspire Consulting Ltd are a private and independent company who have provided expert Supportability Engineering services for over 20 years. Our Support Engineering services, our training and our software have been deployed across the Defence and commercial sectors to optimise the operational performance and through life cost of complex systems.

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