Upfront Simulations and (Their) Democratization – Where We Are?

Anže Čelik
Poclain Hydraulics d.o.o., Žiri, Slovenia
anze.celik@poclain.com.

Upfront simulation involves activities in the early design phase. The goal is to identify potential problems early, optimize designs, and predict performance when changes are cheaper and easier to implement. Democratization of simulation is understood as making simulation tools accessible to non-simulation experts within a company, organization, or community. This means removing barriers that limit product managers, designers, or even non-experts from running simulations and making decisions. The paper presents current status regarding upfront simulations and their democratization within company Poclain. The practical cases demonstrate the abilities brought through the upfront (or front-loading) simulations. It is also explained what activities have been made to democratize (deploy) simulation tools among the group of design engineers. The power of upfront simulations is also demonstrated on real case example, performed in real time (in-situ) at the conference. It emphasizes its ease of use, the importance of understanding the product behavior as well as the gain in time to market.

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1 Buzzy words

If one searches for the explanation or the meaning of **upfront simulation**, there are dozens of different explanations, interpretations and words used for the same (or similar) meaning ... such as upstream simulation, simulation-driven design, simulation-led design, etc. One can quickly get confused.

As with most buzzy words, upfront simulation and/or democratization are interpreted differently by different people. But all would likely agree on the broad sense of its meaning: the goal of simulation democratization is to empower more people to take advantage of simulation technology (Figure 1). On the other hand, upfront simulation means simulation activities being performed early in the design stage. ([1] to [8])

Figure 1: Simulation democratization, an example.
Source: own

1.1 To diminish the misunderstanding

The source [2] gives a meaningful example what it is meant by "democratization" – it explains the term on GPS (Global Positioning System). Deploying a GPS is not an easy task. One needs a knowledge of wireless communications, orbital mechanics, general relativity, and a whole lot more. Locating oneself with a GPS used to require just as much expertise, in the form of specialized equipment and operators who knew how to use it.

The complexity of GPS has not changed. What has changed is who can effectively make use of it: everyone. If one owns a smartphone, he has access to GPS. He does not need any knowledge of GPS to use it – he just pulls up Google Maps and tell it where he wants to go. The details are irrelevant to the end user.

The same idea lies behind the democratization of simulations.

Looking at past technological precedents, one could argue that Henry Ford saw the value of democratizing the ownership and use of motor cars a century ago by making them more consistent and affordable, and Steve Jobs created a market for smart phones a decade ago that was very different to what had gone before - allowing for the democratization of such technology. Even the worldwide web associated with the internet of the last 30 years is a form of democratization because it shares information globally. We are in an age of democratization in so many ways [8].

1.2 How did we understand those words at Poclain?

Simulation tools have been part of design process at Poclain for decades (starting much before the 21st century). In the early stage, FEA (Finite Element Analysis) has been introduced by means of dedicated "FEA expert" and later on by small team of "FEA experts". Then, 1D simulations were implemented as well. But again, they were used only by dedicated team (Figure 2). Later, CFD (Computational Fluid Dynamics) was brought into the company and was used only by single "CFD expert".

Figure 2: The early team of simulation experts.
Source: own

It needs to be mentioned that in the beginning (as well as later on), the word "simulation tool" mainly refers to the use of standalone advanced simulation tool. A lot of practice was/is necessary to be autonomous and experienced user.

Later, the number of simulation users increases year by year (Figure 3).

But still, those users mainly used simulation tools as their "main source", so daily. They were experts in this (simulation) field. By conquering new markets and new (demanding) customers, product portfolio progressively expanded along with the product complexity. Consequently, the need for deeper understanding of products behavior arises; but also, time to market was requested to be shorter and shorter. Those, along with some other reasons and needs, were the main triggers to invest more into the virtual validation (i.e. simulation) approach.

Figure 3: The extended team of simulation experts.
Source: own

As more and more people started using simulation tools, there soon raised the need to unify and standardize simulation procedures. Further, as Poclain started to acquire more companies (ex. Slovenian Kladivar, for example), there was also the need to unify simulation tools (software) as well.

The natural consequence of increasing market needs, its demands and its share, we were faced with the following fact: increase the team of experts or extend the use of simulation tools towards the design engineers (designers).

2 The path to broader leverage of simulation tools

Speaking from Poclain point of view, the leverage of simulation tools should be put in a much global aspect. Tools (any kind) are one of the main pillars of the process, called Knowledge Management (KM). This process has been put in place at Poclain since last decade. But note that KM is also one out of ten pillars of lean product and process development (LPPD). LPPD is a powerful system for developing new products and services, as well as the processes needed to produce and deliver them [9].

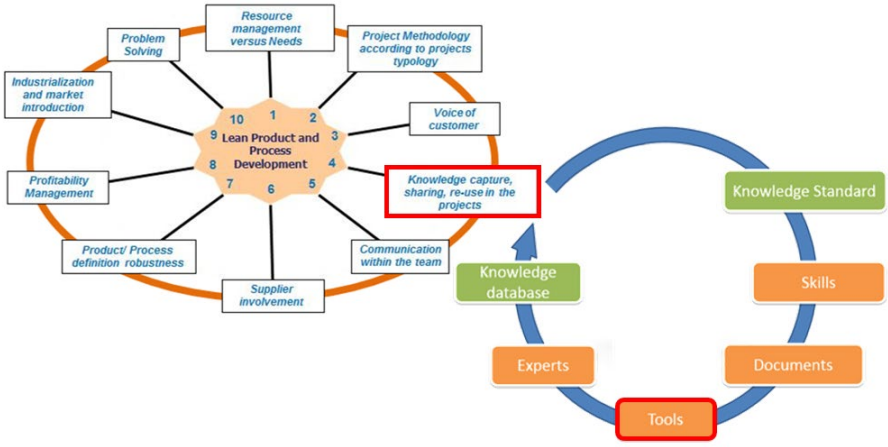

Figure 4: Tools under global aspect of LPPD.
Source: own

2.1 Democratization means changing our mindset

It may not be as easy as simply giving our design engineers simulation tools, and then waiting what will happen. Mostly nothing! Nobody will use the tools. One can go further and provide dedicated training (on-site, virtual classroom etc.). Most often, the result is also predictive – very few people will use the tools. Clearly, there's more to democratization than the simple provision of simulation tools. Similar findings are also reported by [2].

Democratization is a strategic, well-organized path. It can only be successful when an entire organization - from the managers to the analysts to the design engineers – is on board with the shift in thinking. The most difficult thing in simulation

democratization is not the technology itself – it is actually the culture, the mindset, the spirit.

And it usually takes a significant amount of time (years!) to give the right spirit to the team or to the entire enterprise. Poclain was not an exception here. Very in the beginning, project managers did not want to "book time" in a project pipeline to perform simulations because they simply did not trust the outcomes of simulations; top management did not know much about the technology and therefore investment in simulation tools has not been approved from their side; and the last but not the least, designers have seen using simulation tools just as additional (unnecessary) work. So, it has been many barriers to start with democratization.

2.2 Efforts to make democratization live

As just mentioned, changing people's mindset (starting with my own) usually takes the most resources. Here, lots of well-defined activities are incorporated, such as clear presentation (with facts!) of new approach, its added values to the stakeholders, strategic plan of deployment (trainings, workshops …), support, return of investment (for management) etc.

At Poclain, simulation tools democratization started by the group of enthusiastic who, initially, made simulations solely by themselves – mostly even before the concept stage in order to study feasibility and to build missing knowledge bricks. Along with their expertise path, simulation results became more and more aligned with test results and confidence from (project) management, design leaders and design engineers became higher. Consequently, management decided to deploy simulation approach on a design level.

And here, the main effort just started. First, standardized and validated simulation procedures have been established and official simulation tools created and codified (for those purposes, intranet portal has been established, see Figure 5). Then several training documentations have been written, demo cases prepared and training session organized. Last but not least, strong simulation (technical) support has been established in order to minimize bottleneck during design stage. All those training sessions have been integrated later into the Poclain Academy system. Each training document is accessible via intranet portal.

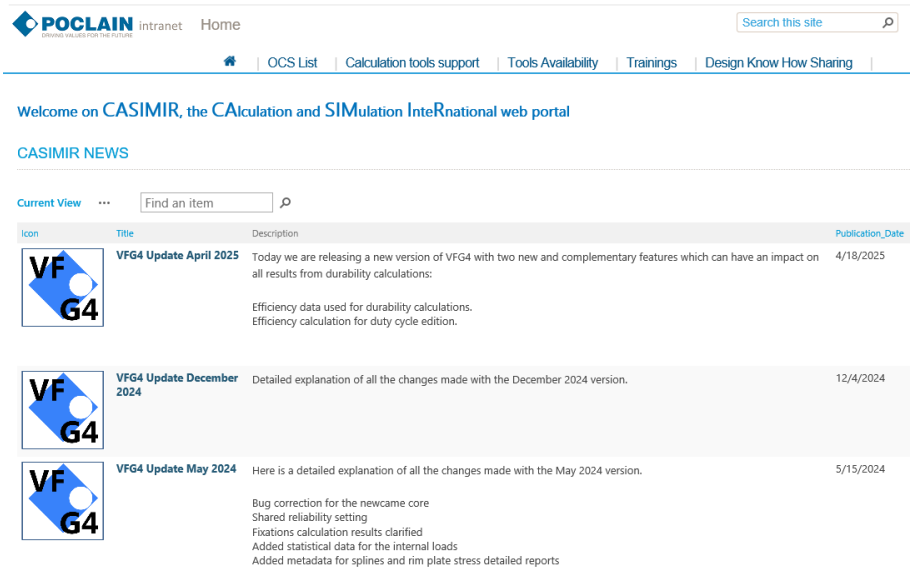

Figure 5: Intranet portal for calculation and simulation.
Source: own

2.3 Efforts to keep democratization alive

Despite numerous training sessions being organized and active support provided, there was still a lack of simulation spirit. Very few people "internalized" simulation tools as a part of their design workflow. Simulation tools with corresponding documentations, training and support were there, but not broadly used within enterprise. To (re)enforce the simulation spirit, additional steps have been introduced. Two of them are explicitly mentioned hereafter: regular workshops and yearly deployment plan (YDP).

2.3.1 Workshop

At Poclain, we found that just "pushing" people to use simulation tools is not the right approach. There is (almost) no lever to use simulation tools efficiently if their users (i.e. design engineers) do not feel "comfortable" with. There is another path we took to convinced users to "grab" the simulation tools – because they like them and because they are familiar with them. This is the path of regular practicing of

simulation tools on real demonstrative cases and showing best practices of using simulation tools. This is the path of regular workshops.

A workshop is an organized event where (limited number) participants refresh their knowledge and skills on simulation tools – simply by quick recap what they learned during the past trainings (e.g. theoretical background, Graphical User Interface GUI tool, methodologies …) and by practicing simulation tool (and methodology) on real case. Note that workshop is not a training, it is a "refreshment" of their existing knowledge and skills (Figure 6).

Figure 6: Internal workshop for the employees.
Source: own

Such a workshop is organized at least once per year for most used simulation tools (numerical or analytical). Each design engineer is invited to join the workshop.

2.3.2 Yearly deployment plan

Yearly deployment plan (YDP) is the process of creating a plan for the successful deployment of new/existing tasks, tools or systems. It involves identifying the resources, tasks and timeline needed to ensure that the deployment is successful [10].

Through the YDP, we define **where** (on which projects, topics), **who** (design engineer) and **what** (part, assembly) needs to be virtually validated by means of simulation tools. In this way, we promote people using simulation tools and project

managers to book necessary time for such analyses into project pipeline. By this way, there is no more "we do not have time" and much less design "surprises" later in a design stage.

3 Current status of simulation tools democratization at Poclain

There are numerous simulation tools currently used by design engineers and simulation experts. Some of the simulation tools are purely analytical and have been purchased (e.g. compression spring design tool) or developed internally (e.g. hydraulic motor lifetime design tool). The rest of the simulation tools are numerical, which means that they use one or more available numerical methodologies to solve governing equations (originally in partial differential form).

Whatever the nature or the origin of the simulation tools, they are all officially codified and available via intranet portal (Figure 5). Each codified tool is "equipped" with corresponding technical documentations, training sessions, associated skills and contact reference (i.e. expert for dedicated field of physics).

3.1 Upfront simulations

So far, nothing has been said about upfront simulations: what it actually is, how it is linked with simulation democratization, how it has been implemented etc. Let's focus and clarify such questions hereafter. Mechanical computer aided design (MCAD) is the center of all virtual product development processes. Embedding 3D simulation tools (e.g. FEA, CFD, topology …) inside MCAD tools is an effective way of improving user productivity and democratizing the use of such tools [8] (Figure 7).

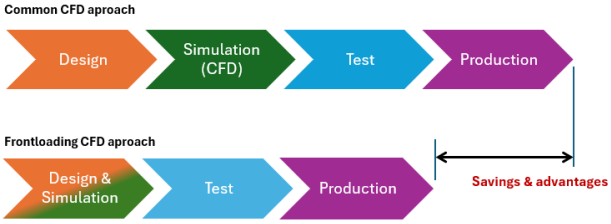

Figure 7: Classic traditional CFD design flow and its relationship to MCAD relative to a frontloading approach.

Source: own

Embedding 3D simulation tools in MCAD also allows for more simulations early in a product development design process where it has the most impact at the least cost. Such upfront or frontloaded simulations within common CAD environments and PLM workflows are done directly on the latest 3D CAD model and provide results in minutes or hours rather than days or weeks.

At Poclain, MCAD package comes from PTC and is called Creo Parametric. It has several simulation tools embedded (Figure 8), such as Simulate (FEA), Flow Analysis (CFD), Mold Analysis, Mechanism, Generative design (Topology) etc.

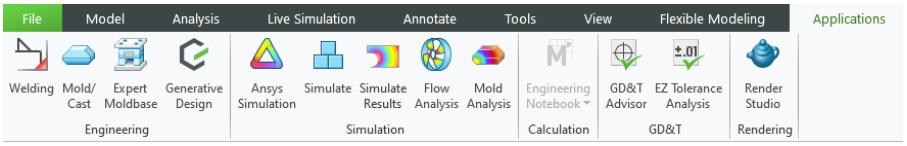

Figure 8: Embedded (simulation) tools within PTC Creo.
Source: own

3.1.1 Upfront CFD simulations

Thanks to embedded simulation tools, each MCAD user has now access to various tools. Embedding computational fluid dynamics (CFD) into native CAD software is definitely one of the biggest factors driving the democratization of CFD. Data generated by CFD is the same as any other product manufacturing information, like mass, visual appearance, kinematics, manufacturing cost, etc.

Therefore, as soon as MCAD user builds his first design idea(s), it could be evaluated by this embedded simulation tools. There is no need to switch to another CAD package or simulation software. Embedded tool also allows to keep (bi-directional) associativity with the main CAD model which significantly reduces iterative simulation loops (Figure 7).

Let's demonstrate the practical use of CFD tool on typical Poclain product: directional control valve (type KV, size 6).

1. Create/import CAD model

In this step, a CAD model is created/designed or imported in any supported format (Figure 9). It is advised to "equipped" part of interest with auxiliary elements (e.g. subplates, fittings …). This is of especially importance if simulation results need to be compared with experimental data.

2. Create new simulation project within the embedded CFD tool

Since there might be several simulation projects within the same CAD model, it makes sense to define meaningful project name (to avoid confusion or misunderstanding).

3. Follows the workflow "left to right" (in the flow analysis ribbon)

Flow Analysis Ribbon (Figure 10) guides CFD user through the complete CFD workflow of preprocessing, performing the simulation and post-processing; CFD analysis starts with fluid domain definition, fluid type (material) definition, physics to consider, definition of boundary conditions, mesh generation and (during pre- or post-processing stage) section planes, plots and monitoring points definition.

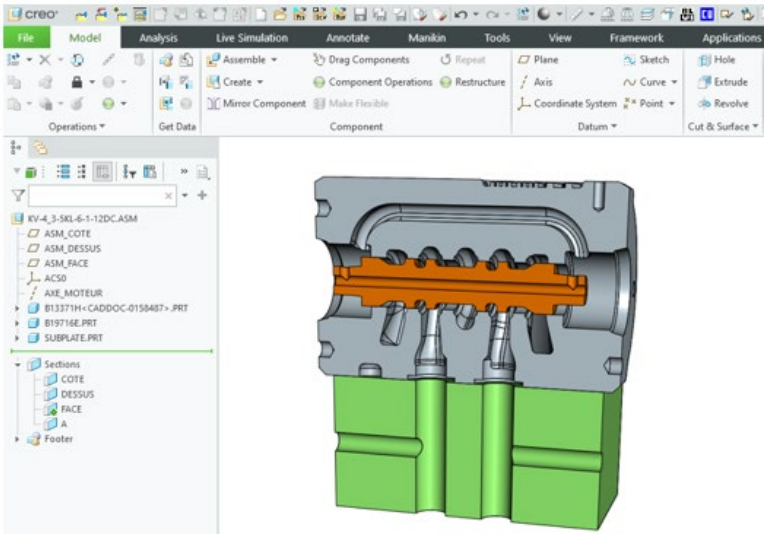

Figure 9: CAD model created within PTC Creo.

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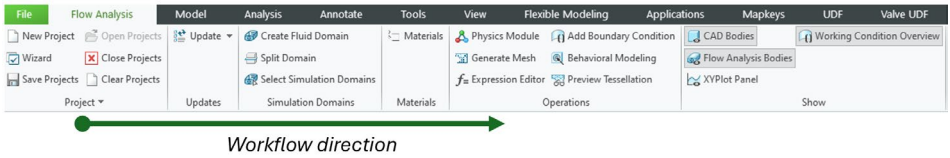

Figure 10: Workflow in embedded CFD tool.
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4. *Run simulation(s) and observe obtained results*

Once a single or multiple projects are set up, simulation run could be performed (single or batch). It needs to be emphasized that runtime is usually very fast due to efficient numerical solvers and multicore capabilities. Then, the second (and very important!) part of CFD task begins → post-processing stage is an "work of art" for CFD user. His skills and ingenuity are key factors to get most from simulation results (Figure 11).

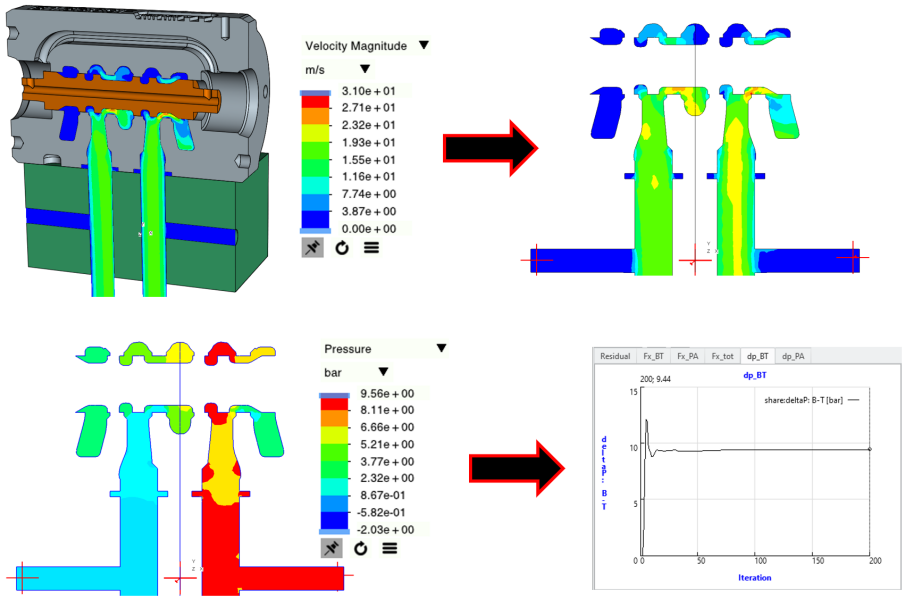

Figure 11: Post-processing activities
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4 Conclusion

The paper presents the general aim, meaning and current status regarding upfront simulations and their democratization within Poclain group. The path that explains the evolution of simulation democratization is also shown. Further, it is clearly explained that simulation democratization is all but not "just push" the simulation tools to design engineers. Otherwise, the result is well predicted – tools are not widely spread. The most difficult thing in simulation democratization is actually not the technology itself – it is the culture, the mindset, the spirit.

The ability and power of upfront simulations is also demonstrated on practical example. It emphasizes the ease of use of simulation tool, the importance of understanding the product behavior as well as the gain in time to market - due to short time from pre- to post-processing stages. Validated simulation tool can make its user more powerful, productive and can provide in-depth understanding of the product in hand. But it is user responsibility to "grab the tool from the shelf".

References

[1] https://pdsvision.com/technologies/simulation/upfront-simulation/, last visited on 24.6.2025
[2] https://www.engineering.com/the-path-to-simulation-democratization/, last visited on 24.6.2025
[3] https://www.ptc.com/en/resources/cad/white-paper/simulation-led-design, last visited on 26.7.2025
[4] hhttps://diginomica.com/ansys-democratizing-simulation-key-reducing-uncertainty, last visited on 26.7.2025
[5] https://www.digitalengineering247.com/article/the-mission-to-democratize-simulation-at-turning-point, last visited on 26.7.2025
[6] https://www.simulationhub.com/philosophy, last visited on 26.7.2025
[7] https://www.engineering.com/mentor-graphics-makes-cfd-meshing-faster/, last visited on 24.6.2025
[8] https://revolutioninsimulation.org/wp-content/uploads/2020/06/THE-DEMOCRATIZATION-OF-CFD-K-Hanna-I-Weinhold.pdf, last visited on 24.6.2025
[9] https://www.lean.org/explore-lean/product-process-development/, last visited on 26.6.2025
[10] https://www.enov8.com/blog/what-is-deployment-planning/, last visited on 26.6.2025