ACCELERATING INNOVATIONS TO REINVENT THE SKY

We live in exciting times. With the demand for new mobility expected to reach $7,9 billion by 2030[1], we see the emergence of startups that are disrupting the market with novel configurations: electrical vertical take-off and landing (eVTOL). Joby Aviation, Vertical Aerospace and the other hundreds of startups must find the right tools to efficiently deliver new sustainable air mobility innovations while minimizing IT-related expenses.

The electrical vertical take-off and landing (eVTOL) sector is now facing increasing competition, and the first company to truly breakthrough into the market will have a significant advantage in terms of publicity, investment and brand recognition; their vehicle will be seen as the standard against which later offerings are judged. As such, the efficiency and integration of engineering tools used in the development of eVTOL concept vehicles is of importance.

Not only the product to be developed is a first-of-a-kind, the company developing it is created from past experience of their founders and employees, but has never built anything yet as a company. The particularity of startups compared to already well-established aircraft manufacturers need a particular answer. Let us see how the **3D**EXPERIENCE® platform from Dassault Systèmes helps startups to accelerate concept to certification to reinvent the sky with their dedicated solution.

ADDRESSING ENGINEERING CHALLENGES

Residents in both established and developing urban areas face a vexing problem: traffic congestion. Despite centuries of effort and billions of dollars' worth of public spending to alleviate over crowded roadways, the problem appears to be getting worse. With an increasing number of cars sharing the road, uncoordinated traffic management and limited parking, commuters struggle while emergency services face increasing delays. According to surveys, residents from London and Bangkok on average spend around 74 and 72 minutes respectively each day commuting to work [2 3], equivalent to 14 whole days in a year wasted simply getting to and from work. This not only increases residents' fatigue but also contributes to carbon emissions and climate change.

To disrupt this dramatic situation, startups have emerged with eVTOL concepts. The promise of these soon to be autonomous, all electric vehicles is to bring 3 to 4 passengers up to 150 miles at 150–200 mph above 5000 ft., consuming only the electricity on board and generating noise on the ground at similar levels currently known with automobiles.

Why now? Battery technology readiness, lightweight composite materials broader use, advanced simulation capabilities, and demand for sustainable urban mobility. Innovators are starting up their businesses from past experiences in the field, breaking the chains of traditional aircraft manufacturers regarding such innovation. It is to note that the latter are investing in the startups[4], or trying to compete by themselves in the eVTOL challenge (such as Bell), recognizing the interest of a profitable market, attracting $2 billion total investment[5].

Beyond the challenges of eVTOL technology by itself, the development of such innovation by startups is bringing its own set of challenges:

- Be first, being able to produce as fast as possible a prototype.
- Be agile, to adapt the investments on cash flow coming from investors funds. Peak and downturn periods of activity and money will successively happen.
- Be unique, as operators are willing to provide a unique mobility experience, enabled by a high level of customization. A high level of competition exists between all players and differentiation is a way to emerge with a competitive advantage.
- Be safe. To reach the type certificate and be allowed to fly, the novel aircrafts must demonstrate to certification authorities that overall safety is met and that airworthiness requirements are satisfied by a substantial margin. With the use of brand-new technologies, the certification is a challenge that needs to be well anticipated.

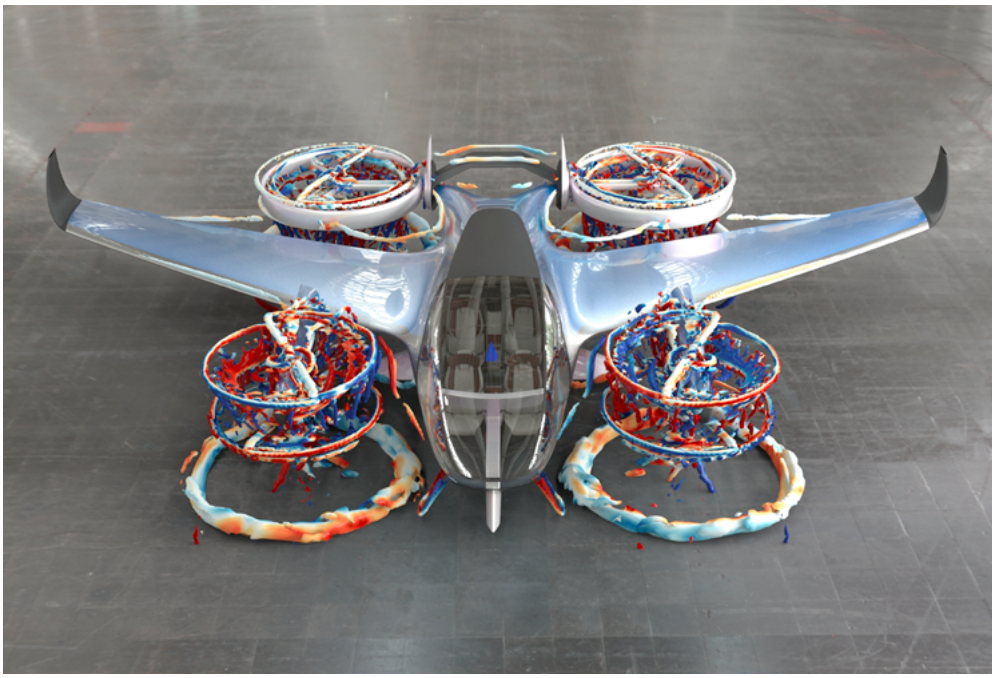

Figure 1: Simulation of an electric vertical take-off and landing taxi created by Dassault Systèmes.

BE FIRST: DIGITAL CONTINUITY AND SYSTEMS ENGINEERING

The development of an eVTOL involves different experts, with various competencies: aeroacoustics, structure, systems, battery or avionics. The aim for the engineers is to promptly get into the design to deliver a prototype as fast as possible. But rushing into designing a solution is not the best way to save time on the long run. Traditional design thinking focuses efforts on the solution of the problem, without having properly defined what the problem is. Stakeholder requirements, regulatory constraints, mission profile and use cases are typically skipped, or considered too late by the designers. If a change in the specifications occurs, by the time design choices have been made, the cost of resolving the cascade of changes increases dramatically compared to if identified earlier.

Systems engineering practice requires self-control to take a step back and set the scene before actually deep-diving into design. This is the role of architects to, first, model the multi-modal transportation system of systems and understand the problem that the eVTOL is trying to solve. Second, create the best solution architecture out of the different possible alternatives of configuration for the eVTOL: how many rotors, tilting rotors / tilting wings or lift-plus-cruise. And third, orchestrate the different disciplines implementation to they achieve the same goal. The 3 step approach is formalized in a methodology called "Cyber MagicGrid" (Figure 2), providing a single framework for the engineers.

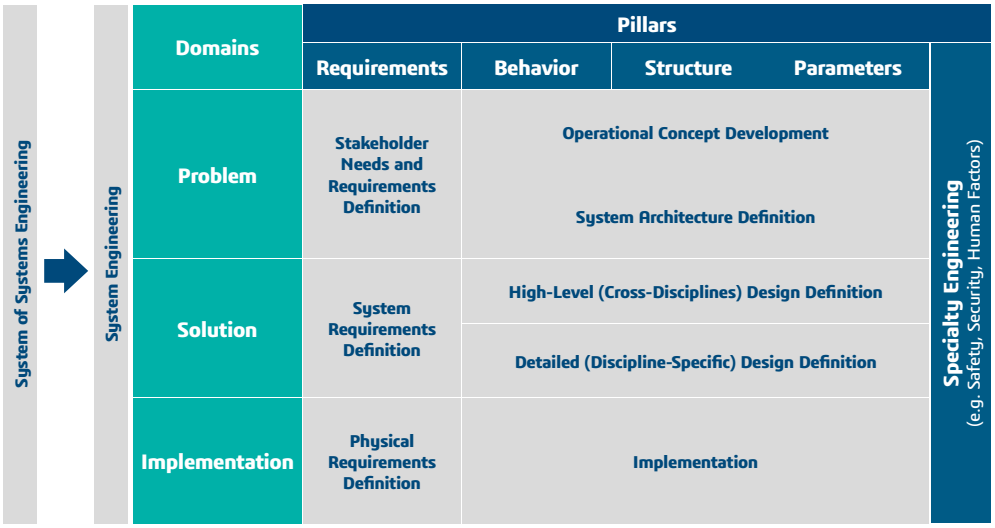

Figure 2: The Cyber MagicGrid methodology for systems engineering, splitting the engineering effort into 3 domains.

The time invested in very early phases turns out to be the winning strategy to actually save time, by anticipation of problems associated with systematic approach. The final design requires fewer changes when experts leverage systems thinking and simulations at different scales, system levels and disciplines:

- At system of systems level to evaluate what mission and performance (i.e. cost of one trip, time of typical trip) would answer the market needs.
- At aircraft level, for community noise assessment and user acceptance for example,
- At systems level for battery system engineering & off-the-shelves batteries integration,
- Up to part design optimization and composites engineering,
- Until manufacturing process simulation for the industrial system,
- Delivery, service & operations at vertiports,
- Disposal and recycling of the major parts of the eVTOL, including batteries.

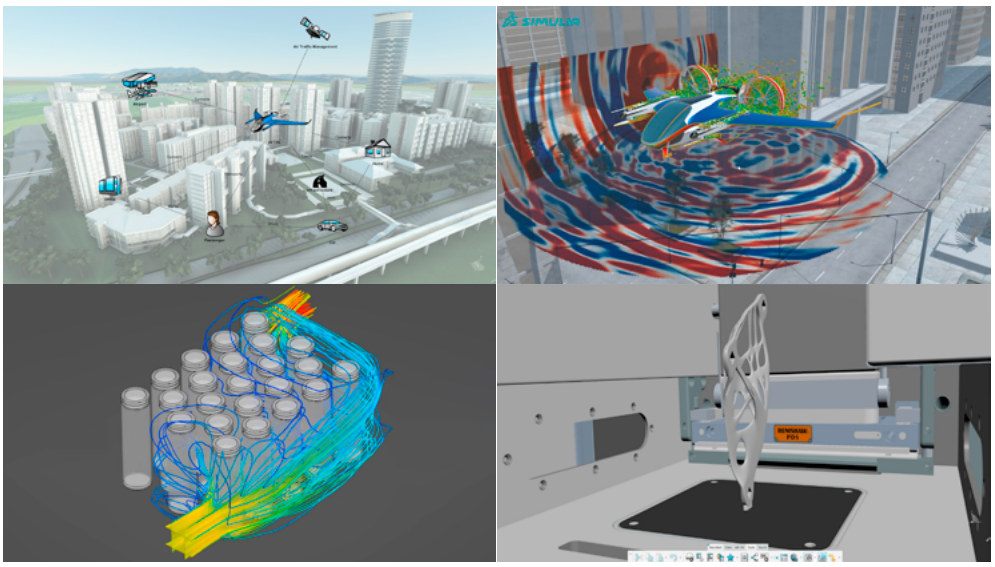

Figure 3: From system of systems model to noise computation, battery pack thermal management and part additive manufacturing simulation.

The end-to-end view of the product lifecycle, from concept to operations and disposal, considering all aspects of the product, enables a true virtual twin of the product.

Now as several teams interact together, they have different modeling & simulation needs that are inherent of their discipline. An architect will draw his/her architectures using SysML (Standard systems modeling language) and specify the systems requirements in a document, whereas an electrical engineer will layout his/her electrical wire harness design in 2D schemas, and finally a mechanical engineer will sketch in 3D the early mechanisms and early shapes. The problem will be to enable the collaboration within those teams that use different formats and languages to exchange information (Figure 4), even though a startup has of very small teams.

Organizing the different engineering activities around a single business platform is key to save time. The platform will be the repository of the models and will animate the data evolution and data sharing. No question where the data is, if it is the last version or which configuration it applies to, the platform becomes the authoritative source of truth. Moreover, it recognizes the particularity of each design group and provides authoring tools to help capture the design intent. If the startup is using a legacy or third party tool, the openness of the platform will integrate the data, enabling digital continuity.

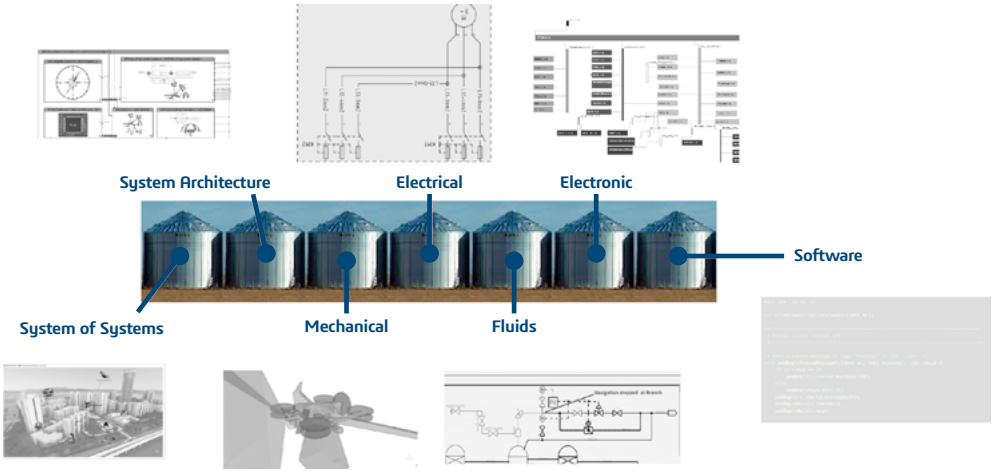

Figure 4: Discontinuity in use of heterogeneous tools by different disciplines.

To be first on the market with a prototype, teams must collaborate and make sure they connect the dots within the platform:

- It accelerates productivity compared when using disconnected and incompatible tools where time is lost in exchanging and converting information
- It improves business flexibility and efficiency
- It enables a controlled program execution with invisible governance
- It provides a seamless transition from engineering to prototyping and manufacturing

BE AGILE: CLOUD AS A BUSINESS MODEL

In traditional days, when a company is seeking capabilities of product lifecycle management and computer aided design (CAD) tools for their teams, they install and operate on premise, thus bearing the infrastructure by their own: they install servers, software and maintain those over time. There are additional hidden costs of on premise installations, which represent a heavy burden for limited resources companies like startups: outages, depreciation, insurance, power and cooling etc. (Figure 5).

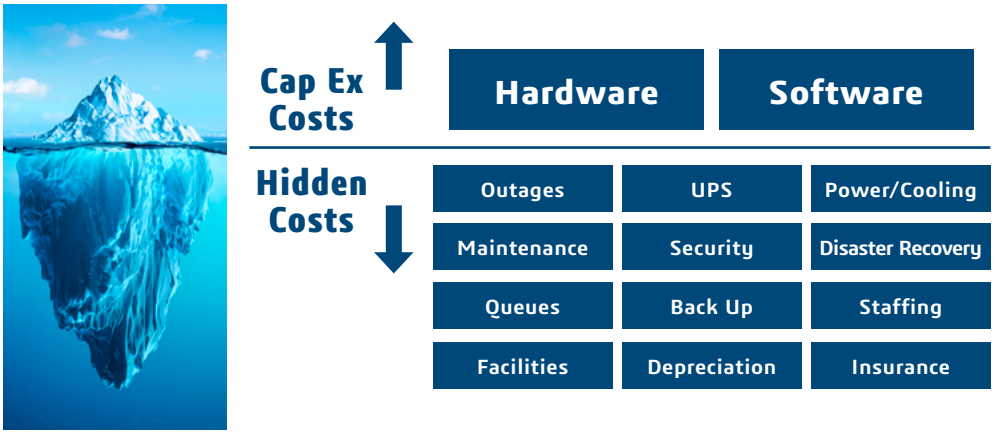

Figure 5: Hidden costs of on premise installations.

When on premise, the company will likely keep a specific software version for a long time, thus not taking advantage of new capabilities developed by the software provider. Moreover, upgrading to a newer software version can be time consuming and disrupting the production effort; something the startup more than the other large OEMs IT staffs cannot afford.

Transitioning to an infrastructure on the cloud is the capability to defer the on premise installation, in-house environments to a third party, secured, infrastructure as a service (IaaS) or software as a service (SaaS). The company will close down their data centers and rely to a cloud-first strategy for a maximum of their applications. It enables startups to focus on their main task: the development of their eVTOL, around a single enterprise environment. They will benefit from the following:

Instant Access to Industry Leading Solution

The availability of the software with SaaS is only few days away from the purchase order, drastically reducing installation time. It also enables the startup to take advantage of the same technology available to the largest aircraft makers in the world. Startups can "think big" but "start small" to scale fast, having one objective in mind: the success of their company for the times to come.

Leveraging the Latest Capabilities With Automatic Software Updates

When on the cloud, startups will always use the latest developments from software providers. They have a 15-day window to decide the most appropriate timing for the software upgrade. It is seamlessly done in a few hours.

Secured Environment for Their Intellectual Property

The cloud providers have invested for secured data centers and their investment is amortized across their numerous customers, big and small. The security level is outpacing the startup capabilities in that domain, should they choose to do it by themselves. As such, the startup takes advantage of a properly secured environment when renting their SaaS, at a lower cost compared to on premise architectures.

Remote Access for Users from Anywhere and Anytime

By nature, the cloud is available from any device, any place in the world with internet connection. Working from home is trendy and allows greater flexibility and productivity for the employees.

Flexibility in Application Stack

The cloud business model is very flexible for startups. The applications they purchase can be discontinued to be replaced by others, allowing them to scale and meet project maturity level and company growth.

For too many years small business owners ignored these powerful technologies that would have allowed their employees more flexibility. A cloud business model fits small and medium enterprises' needs, offering access to the same technology available to the largest aircraft makers in the world, and establishing an agile enterprise referential for collaboration.

BE UNIQUE: MOBILITY EXPERIENCE

To be successful and attract many customers, the eVTOL entry into service requires user acceptance in terms of cost per trip, noise and perceived safety, but furthermore, operators are willing to provide a unique, personalized and convenient mobility experience. A journey with an air taxi is the opportunity to enjoy the city skyline as passengers are lifting and cruising from the office to the airport for their next business meeting. Similarly, French transport operator RATP Group together with Airbus explore the feasibility of air taxis in Paris for the 2024 Olympic Games, reaching stadiums from main airports by no time and not for a happy few.

Figure 6: Artist view of a vertiport and approaching eVTOLs at Paris 2024 Olympics Games.

Yesterday's answers to these point-to-point transportation use cases were the helicopter. Unfortunately, it appears to be too noisy, inefficient, polluting and expensive for mass use. The eVTOL, on the contrary, would fit today's need for sustainability, and as startups are reinventing the sky, it is also an opportunity to work on an enhanced passenger experience and emerge with a competitive advantage. To reach these expectations, there are several answers.

Enable a High Level of Customization

The eVTOL can be designed as modules. Every single configuration will fit specific use cases. For example, the cabin layout will depend on whether we want to maximize passengers capacity on shorter routes or maximize battery capacity for longer ones. During downturn time periods, the eVTOL can be reconfigured as emergency vehicle to accommodate a patient and necessary medical supplies.

Figure 7: Cabin modularization concept for an eVTOL

In this situation and to secure a profitable business model, the startup will not only have to engineer one eVTOL but a family of products or product line. This effort is not limited to opportunistic reuse but should be taken into account profoundly in the enterprise. Product line engineering is a common activity for the automotive manufacturers and is deeply established in their enterprise architecture. Now is the time for the Aerospace industry to progressively endorse this best practice. To support it, configuration management tools are useful to capture the different features composing the product catalog, and to apply them into the design elements. We end up with a configurable 150% structure that reflects the possible combinations. The engineer will make sure the configurations are consistent and that the modules can properly be exchanged from one to another.

Increase Perceived Quality

The quality perceived by the public is a critical factor in the experience uniqueness and in the concept acceptance. We emphasized earlier the need of simulations to verify and validate the eVTOL design against the project top objectives. Physical simulations will play an important role to ensure passenger satisfaction is met, human factors are analyzed and overall quality is achieved. Efforts will be made to optimize the line of sight of passengers, choose the proper materials to avoid sun reflections, and remove parasite noises.

Convince Customers and Investors

3D universes will be leveraged to put the eVTOL concept in action, playing the mission in a realistic environment. By wearing virtual reality helmets, investors are invited to join the experience to understand the innovative concept, developed by the startup. This is a way to demonstrate that it is a winning concept in this promising urban air mobility market and it is worth investing in the startup.

Figure 8: Virtual mobility experience dedicated for engineers and external stakeholders to demonstrate the eVTOL.

BE SAFE: TYPE CERTIFICATE

To reach the type certificate and be allowed to fly, the company must demonstrate to certification authorities that safety is met for their vehicle. The existing type certificates for conventional rotorcraft or fixed-wing aircraft did not match the particularities of eVTOL configurations. The current framework was initially designed where propulsion was mostly provided by piston or turbine engine, and the introduction of new technology and mobility concepts pushed for new requirements and means of compliance. Indeed, the European Union Aviation Safety Agency (EASA) released in May 2020 a special condition for small-category VTOL aircraft, helping startups to share the same understanding of safety with EASA and be able to properly steer design choices to achieve airworthiness[6].

To prove that the required performance is met, the startup will leverage virtual simulation to iterate at low cost on the design. They can explore several solutions before finalizing the test on a real physical prototype. Specific tests are required, like bird strike hitting the vehicle, or lightning strike. Traditionally, companies were in trial and error, testing a limited amount of configurations and not achieving an optimum. With simulation, the iteration is automatic and multi-physics can be coupled.

Not only is it necessary to prove that the required performance is met, it is also mandatory to justify how the conclusion was built. Therefore, traceability between regulations, requirements and design solutions must be enforced as early as the engineering activities have started. Single source of truth helps companies to benefit from a digital continuity of data and keeping the design intent clear to certification authorities.

To reach the type certificate, companies should plan, execute and monitor their certification effort to orchestrate all the stakeholders to produce the necessary deliverables. Failing to do so may require retro engineering of the proofs and may introduce delays to certification.

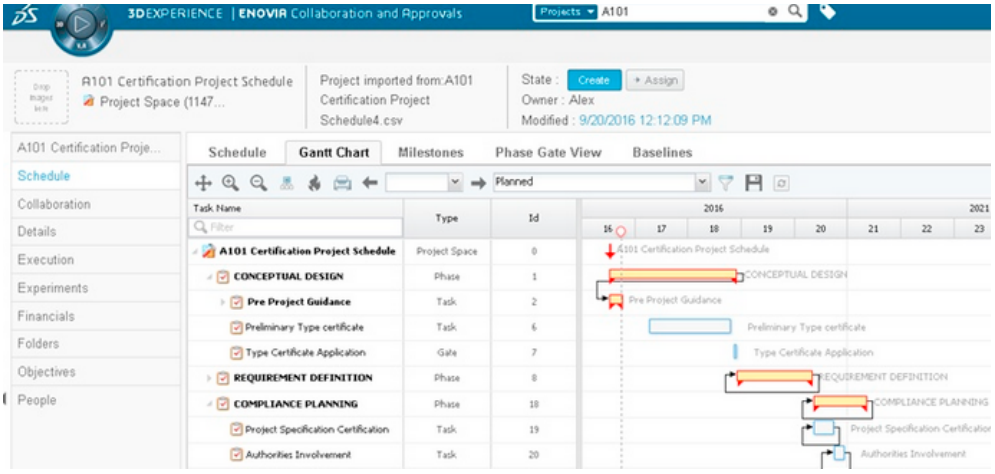

Figure 9: Management of the certification engineering effort.

The platform helps startups to build a regulations pipeline and crawling airworthiness authorities websites. It creates a scientific pipeline that manages means of compliance, virtual models, methods, mathematical formulas and previous results. It helps also the decision makers by providing summarized information through dashboards: certification project status, tests campaign monitoring, submissions and issuances.

CONCLUSION

When electric vertical take-off and landing vehicles will be a success, they will represent one of the most incredible leaps in the transportation history. The biggest hurdle for industries developing eVTOL vehicles is convincing the public and the investors that air taxi is a safe, affordable, sustainable and attractive alternative to ground transportation. Digital prototyping offers a strong value in the era of urban mobility. The Reinvent the Sky industry solution experience within the **3DEXPERIENCE** platform speeds up the eVTOL development cycle with the ability to model, analyze, simulate, certify and experience the eVTOL vehicle in a virtual environment, with enhanced collaboration and communication across all disciplines. This is even more compelling when one realizes the cloud-based **3DEXPERIENCE** platform is easily accessible to everyone, everywhere, to strengthen collaborative innovation – truly leveling the playing field for companies of all sizes.

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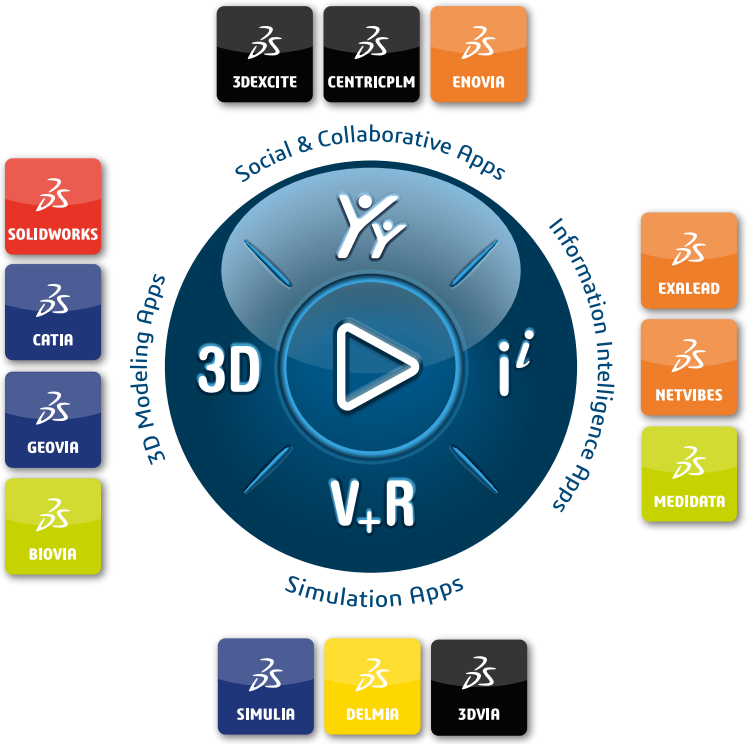

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