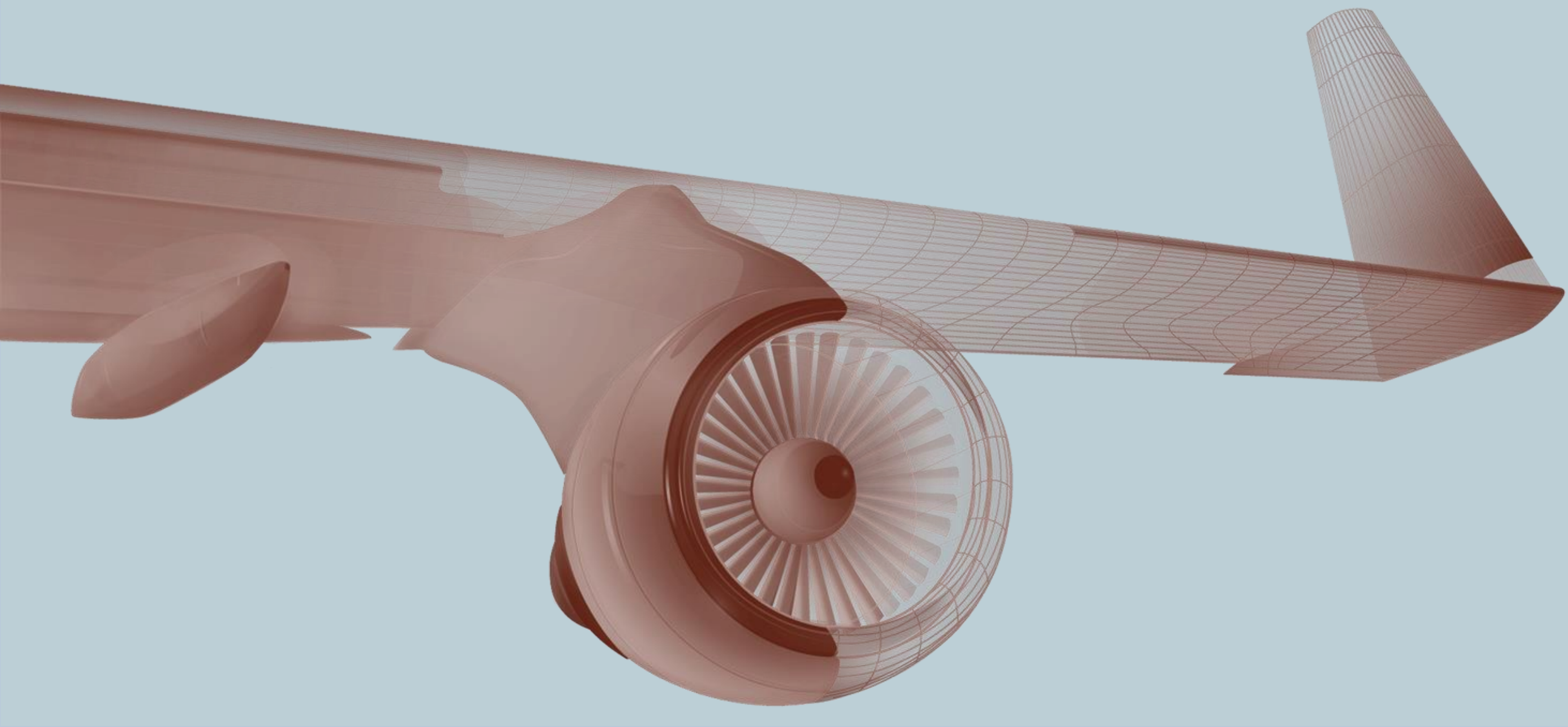
IMPROVE PROGRAM EXECUTION WITH INTEGRATED SIMULATION

LIFECYCLE INSIGHTS



BETTER INSIGHT REQUIRED

The environment for running aerospace and defense programs is only getting more difficult. Funding in many areas is being cut and fewer and smaller projects lead to more competition.

Under such circumstances, many companies are looking for ways to improve their program execution. A recent PLM study from Lifecycle Insights' shows that only 18% of all A&D programs and projects are delivered on time without disruptive shifts in resources. Furthermore, the study shows that increased failures during prototype testing result in decreasing the likelihood of launching programs on time. It is clear that better insight into product, system, and system of systems performance is needed earlier in the program cycle.

Of course, organizations use many different technologies to gain insight into product performance at different phases of the program. In concept design, these tools help define feasible bounds of performance. In contract bidding, they enable better-informed teams to bid more accurately, thus protecting profits. In detailed design, they provide engineers guidance on daily decisions, so that designs are more likely to pass prototyping and testing the first time. Even in prototyping and testing, simulation allows teams to understand secondary and tertiary failure modes.

However, specialized tools come with challenges. Although the results and the data they generate are very valuable, they are almost uniformly disconnected; they are run manually, and their results are spread out all over the organization. As a result, early insight into performance is often lost and must be recreated in later stages. In some cases, the manual burden of conducting these analyses is so high that some organizations cannot run at all, leaving their stakeholders in the dark with respect to performance. These specialist tools are incredibly powerful, but organizations cannot fully leverage their capabilities from one phase of the program lifecycle to another because of these barriers.

New and improved technologies that focus on integrating simulation offer great promise. Multiphysics simulations increase the accuracy of performance prediction and integrate analyses from separate simulation tools. Low and mixed fidelity simulations enable results in early lifecycle stages to connect various analyses, so they offer a progressive path to higher fidelity models. Multi-disciplinary simulation automation and trade studies provide efficiency and deeper insight into product performance. Simulation Intelligence systems provide insight across all types of analysis results plotted against different item configurations. Simulation data management tracks it all, managing files and configurations.

The purpose of this eBook is to cover all of these issues and more. It opens with a look at the pressures driving the need for greater insight into product performance. It then explores the ways simulation can be applied at different stages of development programs. It finishes by analyzing the advantages and disadvantages of both specialist simulation tools and simulation integration technologies.

Better insight into performance is desperately needed in many of the stages of today's programs. The right mix of specialist and integrated simulation technologies can make a powerful difference.

MORE COMPETITION, MORE COMPLEXITY, FEWER ENGINEERS

LESS FUNDING, MORE COMPETITION

Over the past few years, in a trend that has continued over the past decade, funding for aerospace and defense programs has declined, resulting in fewer and smaller programs awarded for development. As a result, contractors and suppliers operate in a more precarious and competitive environment. To win business, they must bid more aggressively. Often, that means they must capitulate on pricing. It can also mean they must commit to overly aggressive time schedules or uncertain program requirements. Once contractors win a program and face detailed development, they can be stuck with an obligation to deliver on infeasible requirements. Ironically, winning these programs can become a serious detriment, as their profitability is undercut by overspending, late delivery, or underperformance penalties caused by these difficult development constraints.

TECHNOLOGY AND SUPPLY CHAIN COMPLEXITIES

Funding issues are not the only source of industry worry. Suppliers have seen an explosion of breakthrough and innovative technologies they need to integrate into products and systems. Today's programs are also increasingly complex, and involve a broader range of organizations that are more widely dispersed around the globe than ever before. Accurately predicting performance for new systems across such a complex global supply chain raises monumental difficulties.

THE IMPENDING ENGINEERING BRAINDRAIN

Another important issue takes a very different form: engineering personnel. In the next few years, droves of engineers in the aerospace and defense sector will be eligible for retirement. As that occurs, a wealth of critically important experience will leave the industry, and organizations will have to forge ahead without the expertise needed to execute programs as smoothly as before. New and inexperienced engineers must step forward and take important roles in understanding the performance of their systems.

TAKEAWAYS ON INDUSTRY TRENDS

The risks to successfully executing development programs are many, including: aggressive contract bids, integration of new technologies, and the loss of experienced engineering talent to retirement.

DESPITE AWARENESS, PERFORMANCE REMAINS POOR

In January of 2015, Lifecycle Insights conducted research called The PLM Study that looked at product development performance as well as the IT environment used to support it (see more details on page 14). The findings uncovered as part of that study include:

- The industry saw 19% of all projects cancelled.
- Another 44% of all development projects outright missed their launch or delivery dates.
- An additional 19% of them required a 10%+ shift in resources to stay on schedule, which disrupted other ongoing projects.
- Only 18% of projects were launched or delivered on schedule without a disruptive shift in resources.

Most organizations find themselves in one of two states: 1) they consistently cancel projects or miss their launch/delivery dates, or 2) they are in a constant state of emergency as they shift resources between projects to stay on schedule.

Certainly more complexity and fewer engineers are contributors to poor performance. However, a lack of or delays in gaining insight into product performance also plays a role. Prototyping and testing are especially important in the aerospace and defense industry, which must comply with stringent regulations and pass numerous certifications. A lack of understanding and foresight into product performance manifests as multiple rounds of prototyping and testing failures. As a result, significant delays and costs are introduced into the overall program.

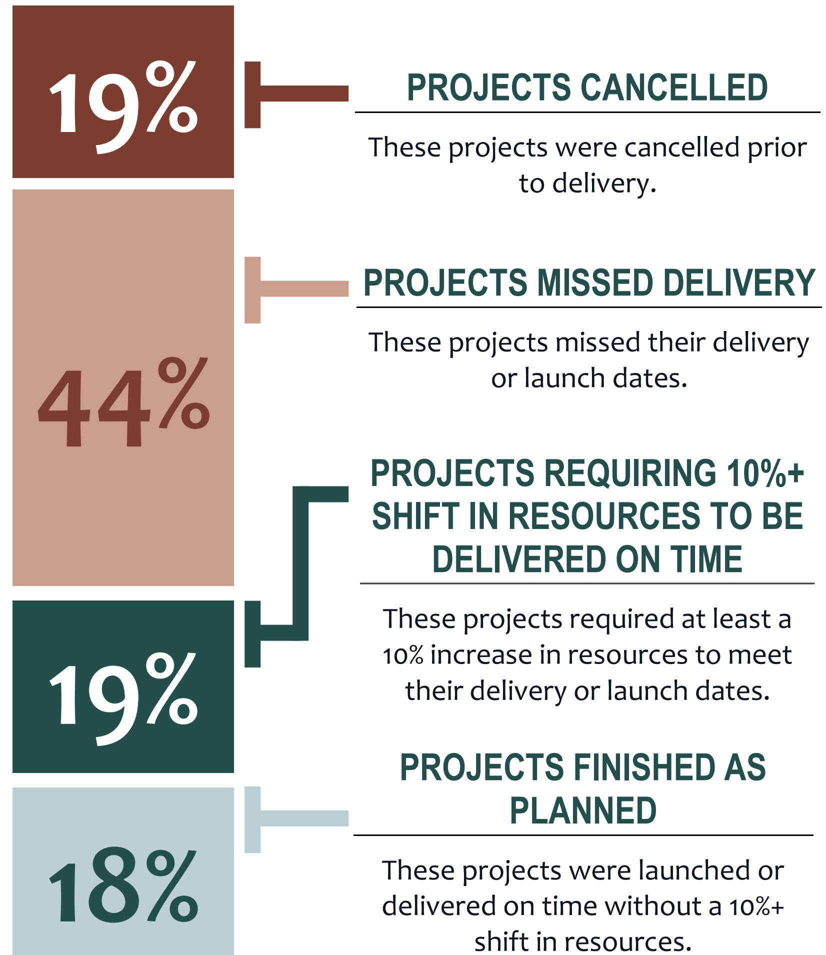


Figure 1: Disposition rates of product development projects, The PLM Study, January 2015, 760 total respondents Aerospace and Defense respondents displayed

A tight correlation between prototyping and testing failures and poor product development performance was another hypothesis of The PLM Study. To test it, respondents to The PLM Study were asked how many projects, on average, hit scheduled design release dates. Respondents were also asked how many projects, on average, had three or more system-level prototypes fail. The conclusion, represented in Figure 2, is that there is a direct connection. The darker areas of this heat map signify where a higher concentration of respondents lie. Specifically, more respondents are in a band from the bottom left to the top right. The trend is visually clear: as the number of projects with system prototype failures decrease, they are more likely to be released on time. The takeaway? Passing prototyping testing the first time increases the chance that a project is released on time.

The outstanding question, of course, is how do you successfully prototype and test a product? Gaining insight into performance *during prototyping and testing* is too late in development, leaving little room to change the outcome. Ultimately, this is where simulation can provide tangible benefits. If used earlier and throughout the product development process, more insight can be gained while impactful changes can be incorporated. Simulation is a critical enabler to successfully passing prototyping and testing in fewer rounds. That, in turn, means fewer delays and costs for the overall program.

		Average number of projects, out of ten, hitting design release dates		
		1 or fewer	2 or 3	4 or more
Average number of projects, out of ten, with 3+ system level prototypes	1 or less	10%	11%	26%
	2 or 3	13%	24%	27%
	4 or 5	16%	20%	18%
	6 or 7	19%	22%	16%
	8 or 9	42%	23%	12%

Figure 2: Heat map of prototype failures against design release,
The PLM Study, January 2015, 760 total respondents
Aerospace and Defense respondents displayed

SIMULATION ACROSS THE PROGRAM LIFECYCLE

Aerospace and defense manufacturers need to utilize simulation to gain more insight into product, system, or system of systems performance. Greater insight would help them avoid multiple prototypes and multiple rounds of testing, and that, in turn, would improve their rates of on-time and on-budget delivery.

While some apply simulation early in development, it is most frequently applied in the verification and validation stages, where it is used to check performance before building a physical prototype. That is a great application of this technology. But it is not the only place simulation can have an impact. In fact, simulation fits within numerous other stages of development.

SIMULATION IN CONTRACT BIDDING

Winning new contracts is always a balancing act. Bid too high or balk at specific requirements, and you lose. Get too aggressive, bid low, or agree to unachievable requirements, and the program is guaranteed to lose money. But how do you know which product, system, or system of systems requirements are infeasible? This is where simulation can play a critical role.

By conducting analyses in the bid phase, contractors and suppliers can make more informed decisions. The proposal team better understands how the potential solution could behave and perform in its operating environment. In some cases, the team can perform trade studies that help counter-propose solutions that better satisfy program requirements. In other cases, analyses allow the team to relax constraints or invest in technology to make the design space feasible.

Using simulation in this phase, however, is not always easy. Most teams are pressed for time and lack the tools and methods to conduct simulation. However, new technologies let organizations capture best practices and automate their analyses. Furthermore, these systems capture the traceable relationships between requirements, design, and analysis in the face of changes.

This means that the company can better understand the profitability constraints of the program. That, in turn, affects how their proposal is developed.

SIMULATION IN CONCEPT DESIGN

At first glance, simulation in concept design would seem to play the same role it does in detailed design. And while simulations can be tactically executed the same way, the purposes of the analyses are fundamentally different. Detailed design simulation ensures that a design fulfills the requirements of its program based on a fairly complete 3D model. Concept simulation, however, can be used to *define* the bounds of requirements and *select* a concept baseline, often without the availability of a 3D model. Furthermore, simulation work from contract bidding should be drawn upon for concept analyses.

The application of simulation in this manner is especially important in technology development and pure R&D environments. In such cases, proof-of-concept technologies often wait to be integrated into future bids and contracts. The key here is to define the exact boundaries of what the new technology or concept can achieve. When that happens, it can be integrated into new programs with the right expectations.

SIMULATION IN DETAILED DESIGN

In this stage, simulation can be used to guide design decisions on a day-to-day basis. Whether everyday engineers or expert analysts conduct it, the idea is to perform comparative simulations that allow the sizing of components, the selection of components and refinement of overall designs.

The result benefits everyone downstream. By the time a design reaches prototyping and testing—or even verification and validation—it has been vetted more thoroughly. This, in turn, increases the likelihood of passing those checks the first time, instead of requiring multiple attempts.

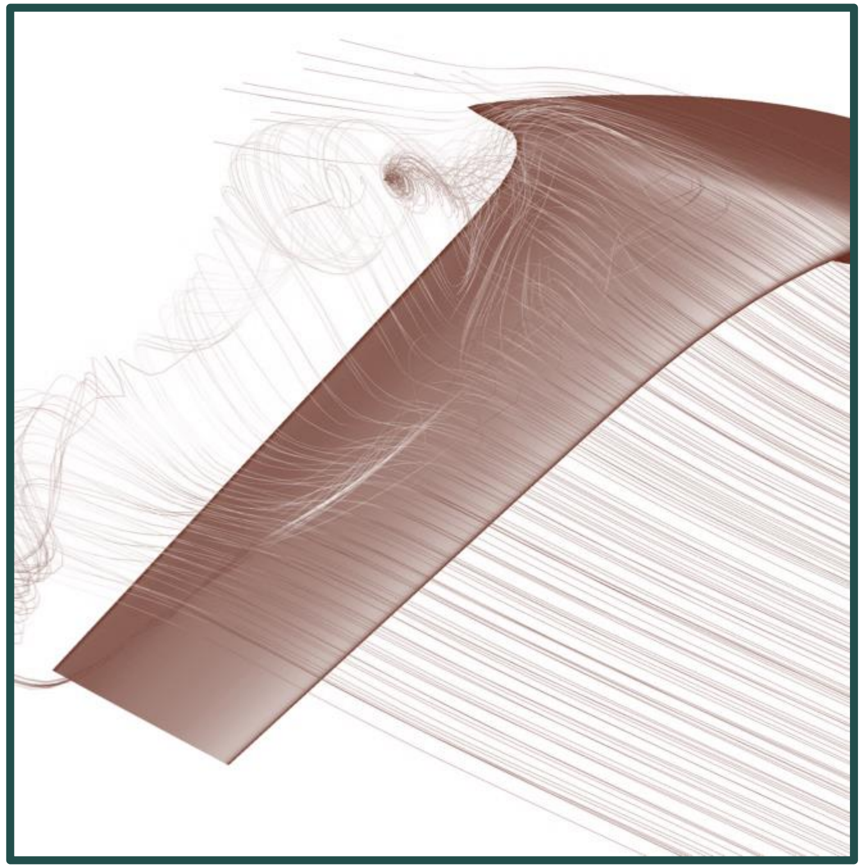
SIMULATION IN PROTOTYPING AND TESTING

It may sound strange that simulation can actually be useful in this phase, as it is supposed to enable designs to pass quickly through prototyping and testing. Yet it provides great benefits.

Failures during prototyping and testing only reveal the first failure mode encountered. Additional rounds can reveal secondary, tertiary and other failures modes. But as research findings indicate, multiple rounds of prototyping and testing contribute to the failure to meet program delivery dates. Simulation shows multiple failure modes all at once. Used in this phase of the program, simulation reveals those failure modes and allows teams to validate them. In turn, engineering teams can take corrective action against all of these failures at once, as opposed to sequentially.

TAKEAWAYS

Simulation provides immense value through its use in verification and validation. However, aerospace and defense companies can reap strong benefits by applying simulation throughout the entire lifecycle of the program, notably in the bidding, concept design, detailed design, and prototyping and testing phases.



SPECIALIZED TOOLS: VALUABLE YET DISCONNECTED

As we have seen, simulation is valuable in many phases of the program. Today, aerospace and defense organizations commonly use a wide range of specialized technologies to predict performance. Although these tools provide great value, they are often disconnected or poorly managed during the contract bidding, concept design, detailed design, and prototyping and testing phases. This necessitates recreating prior work, and leads to inaccurate analyses or a failure to conduct simulations at all.

CUSTOMIZED AND CONFIGURED SPREADSHEETS

Spreadsheets are one of the most widespread technologies used by aerospace and defense engineers today. In the context of understanding performance, they have multiple uses. They are often used to keep track of the configuration of the system being virtually tested. Although they are often not recognized as specialized tools, spreadsheets can be extensively customized to include finely tuned formulas and equations that have been developed internally over time. Their flexibility and customization provides the functionality needed to model almost any specialized performance measurement.

Spreadsheets also provide integration capabilities that enable them to interact with—and integrate calculations and simulations from—other software solutions that specialize in other physical domains. However, this specialized functionality is rarely utilized, resulting in silos of performance data that are not reused or leveraged forward into other stages of development.

Why is this important? In aerospace and defense, performance is rarely constrained to one physical domain. For instance, engineers might need to determine the behavior of metal and composite materials operating in tandem. Fluid dynamics simulations directly affect aero-structure calculations. Spreadsheets used for one of these applications truly need to be connected to simulation technology used to predict behavior of the other phenomena. Ultimately, more collaboration and integration are needed.

TRADITIONAL SIMULATION SUITE

Another specialized technology commonly used by engineering organizations is a traditional simulation suite of software, which includes a pre-processor, solver, and post-processor. These tools are most frequently found in the offices of expert analysts dedicated to conducting simulations all day, every day.

These expert-oriented tools are powerful aids to understanding the performance of a single configuration of a product or system within a few physical domains. Furthermore, some of them automate the exploration of design alternatives through optimization, sensitivities and design of experiment (DOE) studies.

However, these suites often don't facilitate the integration of mixed fidelity models, which include 1D, 2D and 3D simulations. Such analysis models are often critical during the concept phase, where behaviors are known but the shape and size of the design is still abstract. Another drawback: these technologies need specialized knowledge to set up simulations properly, requiring a team of simulation analysts to be accessible during detailed design. Furthermore, these tools need a fully detailed 3D model for high-fidelity analyses, which typically are only available late in the detailed design phase.

Traditional simulation suites provide great value to the expert simulation analyst team, but they are not accessible to those who need analysis capabilities in the other phases of the program lifecycle. Nor do these tools integrate mixed fidelity models, a key capability for early stage and system of systems work.

DESKTOP AND LAPTOP FILE MANAGEMENT

Whichever simulation technologies are used to model performance, a common practice is to keep the resulting files on individual desktops and laptops. This approach is convenient, but it carries significant risks. Crucial models and calculations can be lost when hard drives go bad, or they can easily be misplaced amid hundreds or thousands of files. This undermines efforts to build engineering knowledge over time. Furthermore, this method of file management carries legal risks, as more programs require a trail of decision-making that can be audited.

Another problem is that others involved in the program cannot readily access and reuse files on someone's desktop or laptop. Thus, a completely new effort is needed to simulate the performance of a slightly different product, system, or system of systems.

Despite the risks and disadvantages of managing simulation artifacts on desktops and laptops, it is a widely proliferated practice. Findings from The Simulation Driven Design Study, conducted by Lifecycle Insights, show that 51% of all respondents use these technologies to manage simulations.

TAKEAWAYS ON SPECIALIZED SIMULATION TOOLS

Ultimately, the simulation tools used in the various phases of the program lifecycle are valuable. However they are often disconnected which forces stakeholders to recreate prior work, again and again. Furthermore, they require specialists to perform manual tasks and micro-manage the work done with the technology. Therefore, there is room to augment them with new technologies.

INTEGRATION TOOLS: POWERFUL AND ADDITIVE

These solutions are accessible to an ever-broadening range of product development stakeholders. That translates into real opportunities to augment specialized simulation tools in the concept design, contract bid, detailed design, and prototyping and testing phases of aerospace and defense programs.

MULTIPHYSICS SIMULATIONS

The operating environments for products, systems, and system of systems are not constrained to any one physical domain. In reality, physical phenomena combine and interact in ways that are hard to predict. For example, due to thermal coefficients of expansion and high operating temperatures, internal components of aircraft engines must be designed in an 'expanded' state to work properly. The metallic internal spars and longerons of an aircraft are bonded with a layup of composite materials to make one combined wing-aerostructure. Furthermore, this multifaceted structure interacts with the fluid flow of air to produce complex structural behaviors such as wing flutter.

The capabilities offered by simulation integration tools allow analyses across physical domains to be combined or coupled, more closely emulating this reality. While this functionality offers more accurate predictions, these simulations are also accessible to everyday engineers—another key advancement—via easy-to-execute templates. These tools have been enhanced to make such analyses easier and to quickly combine physics effects, so much so that non-experts can use them in earlier stages of the program lifecycle.

LOW FIDELITY MODELS, MIXED FIDELITY MODELS

Up until the last few years, most simulations have derived some form of detailed designs as the basis for analysis models. This has limited the organization's ability to analyze performance until after the detailed 3D model is available.

Fortunately, new methods and technologies have been developed. They can simulate product behaviors using low fidelity representations, including 1D analyses, which rely on formulas and equations without using any geometric representation of the design. They may also include 2D analyses, which use a single view or a flowchart-like model. Such approaches, when set up and executed correctly, can yield incredibly valuable insights into product performance.

Another critical related advancement is the capability to link these different analysis models together to predict the performance of higher order systems. Such mixed fidelity models help the organization better understand system and system of system performance by coupling varying fidelity models.

PROGRESSIVELY MODELING SYSTEMS

Another critical concept that simulation integration tools enable is to allow these models to mature as the program progresses. An early 2D model of the mechanical aspects of a landing gear, used in the system model, can be replaced with a full 3D model once that has been developed. A 1D representation of a control system, in the same system model, can be replaced with the final software code, once it is ready.

Low and mixed fidelity simulations not only make it feasible to run simulations in early lifecycle stages, but also make it easier to mature a system model progressively from concept design to contract bidding, and then from detailed design to verification and validation, and finally to prototyping and testing.

SIMULATION AUTOMATION

Analysis is not composed of a single simple task. It is a process that involves numerous, repetitive steps. Analysts prepare a model for simulation by making abstractions and simplifications. Then they apply loads and constraints, and execute the solution through a solver. Finally, they review and document their results. In many cases, organizations have developed best practices that analysts need to apply to ensure reliable results.

To address this repetition, a relatively new ability to automate simulation processes has been introduced. This functionality operates very much like workflow capabilities, where a given set of inputs is executed to produce the final output. The automated process requires defined interfaces and parameters, but it dramatically increases the completion of simulations in any stage of the program's lifecycle. This functionality is especially powerful when applied to multiphysics and system level models composed of individual analyses. As the component analyses progress and mature, the automated system level model can be re-run quickly.

SIMULATION TRADE STUDIES AND OPTIMIZATION

Accompanying automation is the ability to execute trade studies and optimizations against simulations. Users define the ranges within which design parameters can vary. Multiple simulations are then executed using those varying design parameters as inputs. The ensuing set of results provides deep insight into the design space. For an extension of this functionality, design parameters can be modified to optimize performance. Automated system level models can then be executed through trade studies. This can be done as the component analyses are upgraded to higher fidelity representations.

Ultimately, integrated simulation tools carry great potential in early lifecycle stages. The benefits are numerous. Concept designs can now possess clear performance boundaries. Alternatives for contract bids can be optimized for performance, cost, requirements, or other constraints. Detailed design simulations can be automated for feedback on every design decision.

SIMULATION DATA MANAGEMENT

At one level, the management of simulation artifacts is all about volume. Analysis generates a *lot* of files. They all need to be kept for safekeeping, for regulatory constraints, and to meet customer requirements. That's a lot to track. Simulation Data Management (SDM) systems help users immensely in this regard.

However, on another level, the files generated by analyses are not standalone. For instance, a specific version of a 3D model results in a specific version of the simulation model. That simulation model yields a specific version of simulation results. This *baseline configuration* of simulation artifacts relationships must be documented and tracked. This traceability is needed to understand which analysis results apply to which design alternative. Simulation Data Management systems take care of these responsibilities for the users, as well.

Ultimately, these solutions are the key to leveraging simulation across lifecycle stages. Without them, it becomes difficult to track which result is related to which design.

SIMULATION INTELLIGENCE

Greater insight into product performance requires more simulation in every stage of product development. Yet, as the amount of analyses mounts, it can be difficult to visualize all of those results, especially compared to one another or in the context of different system or product configurations.

This challenge has led to the emergence of a new kind of solution called *Simulation Intelligence*. This system presents the tangible results embedded within analysis results, even though they may exist in a myriad of simulation formats. It shows that information in an easily digestible manner independent of complex simulation tools. Users can filter the results based on key traits such as configurations, requirements and more. It is a data analytics technology applied to a large volume of simulation results.

Ultimately, these capabilities enable users to better understand the results of the range of analyses that are conducted across the program's lifecycle. With deep insights into the design space, they can make the right decisions to avoid prototyping and testing failures.

THE VITAL IMPORTANCE OF INTEGRATION

Individually, these capabilities provide immense value. Each enables better simulation and analysis in concept design, contract bidding, detailed design, and prototyping and testing. However, each shares a needed capability that may be the most important of all: *integration*. Integration is critically important because these technologies are all interrelated. Each provides capabilities the others need.

- The configuration of mixed fidelity models, especially those that represent systems composed of evolving analysis models, matures over time as the program progresses. Simulation Data Management tracks that configuration to understand which component analyses were used to produce which result.
- Mixed fidelity models must also be closely integrated with multiphysics models. The latters' results are critical to increasing the accuracy of the former.
- Each run through a simulation automation workflow requires varying design parameters. Simulation Data Management must associate inputs and results to clarify which design applies to which results.
- Simulation automation must leverage the more accurate results of multiphysics simulation to provide better insights into product performance.

These technologies offer extremely valuable insights into product performance across the program's lifecycle. However, they must be used in tandem, collectively, for organizations to reap the greatest benefits.

TAKEAWAYS ON SIMULATION INTEGRATION TOOLS

A range of specialty simulation tools provides valuable insights into product performance. Yet, because they are often disconnected and manually run, their ability to provide the insights to avoid multiple rounds of prototyping and testing is limited. Augmenting these tools with Simulation Integration Tools allows organizations to gain greater insights into product performance. Together, these two sets of technologies are the right answer for on-time and on-budget programs.

RECAP AND CONCLUSION

Today, aerospace and defense suppliers face cuts to programs and the loss of engineers to retirement. To win programs, they must submit aggressive bids and agree to difficult requirements. It is therefore no surprise that The PLM Study showed that a mere 18% of all projects are delivered on schedule without a major shift in resources. Findings also showed that multiple rounds of system level prototype failures result in an inability to meet delivery dates.

SIMULATION ACROSS THE PROGRAM LIFECYCLE

Simulation has long been used in verification and validation as a final check before prototyping and testing. However, it holds great promise for other phases of the program. In contract bidding, it provides insight to develop winning bids that also protect profits. In concept design, it defines the bounds of requirements and provides the basis to select a concept baseline. In detailed design, it offers insight into performance for design decisions. Even in prototyping and testing, it helps identify secondary and tertiary failure modes, enabling engineers to address them simultaneously instead of sequentially. In all, simulation holds great promise across the program's lifecycle.

SPECIALIZED SIMULATION TOOLS

Spreadsheets, traditional simulation suites and desktop management all provide value to different stages of the program lifecycle. However, they are flawed in that they are disconnected and require manual intervention in order to provide insight. They can be augmented with simulation integration tools to provide great value.

SIMULATION INTEGRATION TOOLS

Multi-disciplinary simulations increase the accuracy of performance prediction. Low and mixed fidelity simulations provide results in early lifecycle stages and a progressive path to higher fidelity models. Simulation automation and trade studies offer insight into the design space. Simulation Data Management tracks it all, managing files and configurations. Simulation Intelligence helps users make sense of the sea of analysis results from many tools. When paired with today's tools, these technologies can provide deep insight into performance.

FINAL TAKEAWAY

Conducting simulations earlier and continuously across the program's lifecycle will provide the insights into product performance that is key to reducing prototyping and testing. The best approach to enabling those insights is to augment Specialized Simulation Tools with Simulation Integration Tools.

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For more information on Lifecycle Insight's PLM Study, The Simulation Driven Design Study and other publications, visit our Resource Library.

APPENDIX A: LIFECYCLE AND DEMOGRAPHICS OF STUDIES

THE PLM STUDY

The PLM Study researched the state of adoption of Product Lifecycle Management (PLM) solutions as well as its associated organizational performance benefits.

During the first two weeks of January 2015, Lifecycle Insights surveyed 760 respondents to organizational performance and use of PLM related technologies, including data management, project and process automation, sharing and collaboration and development reporting and oversight.

The number of respondents to the survey totals 760. The findings of this study, however, are based on a subset of these respondents, totaling 459 that directly participate in the product development supply chain. Responses from software providers, service providers and system integrators were excluded.

Respondents to the study's survey serve a wide variety of industries, including: 29% Industrial Equipment, 28% Aerospace and Defense, 22% Automotive, 17% Medical and Life Sciences and 16% High Tech / Electronics. However, these industries were not served exclusively. Fully 35% of the respondents designated that they serve more than single industry.

Survey responses for this study were gathered from the following geographic areas: 69% North America, 13% Asia, 12% Europe as well as 4% Australia and New Zealand, South America, Africa and the Middle East.

THE SIMULATION DRIVEN DESIGN STUDY

The Simulation Driven Design Study researched how simulation driven design efforts are setup, run, reviewed and managed in concept and detailed design.

Survey respondents were recruited via Lifecycle Insights and its research partners. The number of respondents to the survey totals was 1,005. The findings of this report, however, are based on a subset of these respondents, totaling 826, which directly participate in the product development supply chain. Responses from software providers, service providers and system integrators were excluded.

Respondents to the Simulation Driven Design survey serve a wide variety of industries, including 40% Automotive, 36% Industrial Equipment or Heavy Machinery, 34% Aerospace and Defense, 18% Consumer Products and 18% Construction. However, these industries were not served exclusively. Fully 20% of the respondents designated that they serve more than single industry.

Survey responses for this study were gathered from fifty-one different countries. The contribution by geographic area is as follows: 41% North America, 36% Europe, 14% Asia, 3% from Australia and New Zealand, 3% from South America, 2% from Africa and 1% from the Middle East.