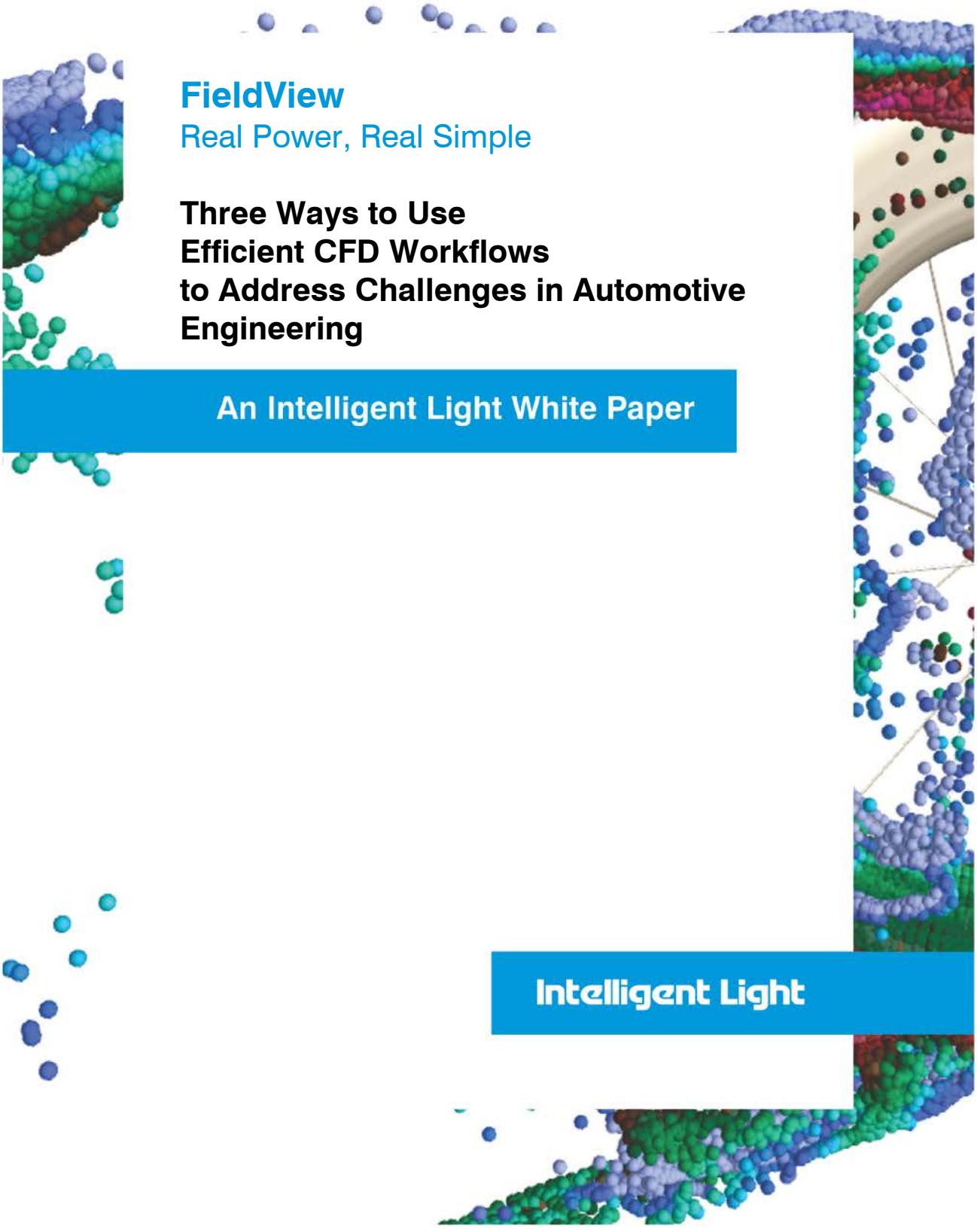

FieldView

Real Power, Real Simple

Three Ways to Use Efficient CFD Workflows to Address Challenges in Automotive Engineering

An Intelligent Light White Paper

Intelligent Light

Solving Industry Challenges with Engineered CFD Workflows

Gaining a Competitive Edge

A streamlined CFD workflow:

- Speeds turnaround time – reduces time to market
- Increases throughput
- Boosts productivity – keeps engineers engineering
- Creates flexible, adaptable, automated processes
- Maximizes ROI in hardware, software, and people
- Exploits organizational knowledge base
- Enhances internal & external collaboration

In the pressure-cooker environment of the automotive industry, all players, from manufacturers to the smallest suppliers, are looking for a competitive edge in getting quality products to market faster. CFD (computational fluid dynamics) can significantly benefit the design and development process by providing new ways to analyze and understand product performance.

Just as computers have evolved into today's high performance systems, CFD software has become more powerful, capable of crunching through the largest, most complex cases and producing huge volumes of results data. The key to success with CFD is in effectively post-processing those results to gain critical insights and turn the data into decisions. Getting to the answers quickly and accurately requires robust, agile tools that are easy to learn and easy to integrate within an organization's unique engineering environment, no matter how small, large, or complex.

Today's winning organizations are employing workflow strategies that make the most of their HPC, software, and human resources. The data management, automation, and visualization capabilities of modern post-processing software can help create a streamlined, highly productive CFD workflow that speeds turnaround time, increases throughput, boosts productivity, and maximizes return on investment in hardware, software, and people.

With compute resources and software handling the 'grunt' work, engineers are able to spend their time engineering, not waiting for a dataset to load or wading through volumes of results. In addition, an automated CFD workflow creates repeatable, predictable processes, helping build an organizational knowledge base to leverage on future projects.

In this white paper, we'll look at three challenges facing the automotive industry and illustrate how an engineered, highly efficient CFD workflow is helping companies meet them.

The Challenges

- **Meeting new and more stringent environmental regulations**
- **Too much data, too little time – getting actionable data *fast***
- **Keeping engineers focused on value-added engineering**

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Meeting new and more stringent environmental regulations

In an automotive product lifecycle already overwhelmed with time and cost concerns, new government mandates only amp up the pressure. CFD engineering teams have to muster every resource to get accurate answers from sophisticated analyses, and bring actionable information to the table quickly in order to impact design for both internal and regulatory approval.

The automotive industry is on the front line in the war on oil consumption and noxious emissions. Since the first CAFE rules went into effect in 1975, passenger car and light-duty truck manufacturers have been driving to ever higher standards for fuel efficiency and emissions. Current rules call for a goal of 54.5 miles per gallon as of 2025.

Now, for the first time, similar standards are being applied to heavy vehicles. The regulations, which go into effect in 2014, impact combination tractors (semi-trucks, or Class 8 vehicles), heavy-duty pickup trucks and vans, and vocational vehicles such as transit buses and garbage trucks. Within each group, even more specific targets are laid out based on the design and purpose of the vehicle. For Class 8 vehicles, the new rules require a reduction of as much as 20 percent in carbon dioxide emissions and fuel use by the 2018 model year.

Meeting new or more stringent rules requires a highly productive CFD workflow that provides the critical tools needed to move forward swiftly and confidently.

Efficiently and effectively responding to new requirements through improved aerodynamics

At Navistar International, a leading manufacturer of Class 8 trucks, CFD is proving its value as the company prepares to meet the new regulatory standards. Aerodynamic performance is a key factor in fuel efficiency. Navistar's aerodynamics CFD workflow runs through Corvid Technologies, a computational analysis and engineering firm, and uses the RAVEN CFD solver and FieldView for post-processing. After sending a vehicle's CAD data to Corvid, Navistar's aerodynamics engineering team works with Corvid analysts to set up the solver run, determining which components and areas to analyze. With unsteady problems on the order of 90M cells, these CFD solver runs require nearly two days to run on a 200-core system.

Keys to Success

- Automated post-processing produces actionable results in an hour
- Simulation provides data that can't easily be captured in a wind tunnel
- Enhanced collaboration through use of images that make complexity easily understood

With just one additional hour of *automated post-processing*, a massive dataset becomes actionable information that would otherwise take days to generate if a human was doing the work. Once the report gets back to Navistar, the aerodynamics team uses FieldView to interact with and interrogate the data. In performance

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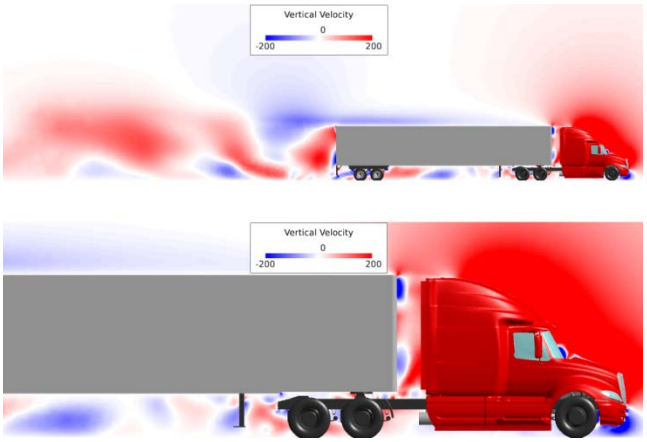


integration meetings, team leaders from all relevant engineering groups – body, chassis, powertrain, suspension, and more – come together to share their findings. Presenting vivid images and animations helps everyone understand the aerodynamics CFD results, both in general and in relation to each component.

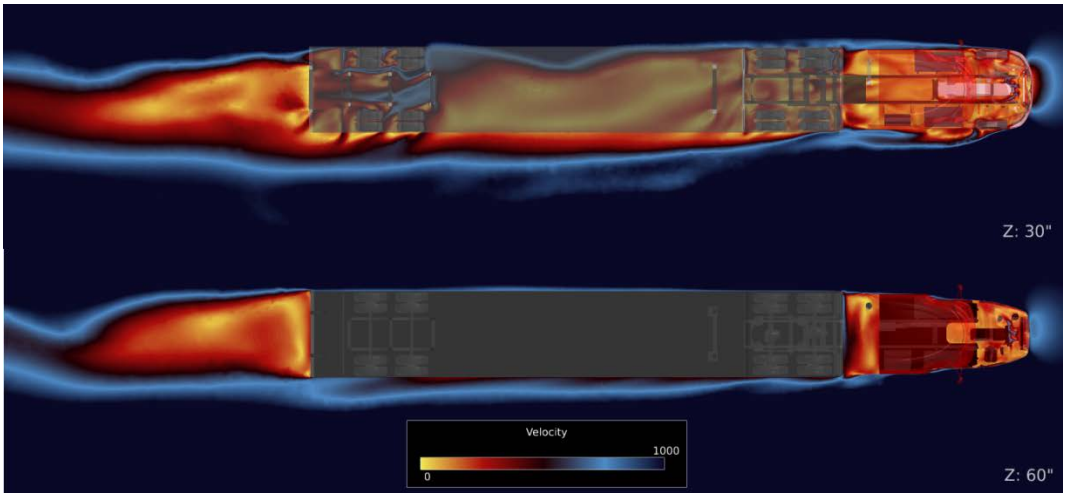
The ability to easily test out and explore myriad configurations is particularly vital when your product won't fit into a wind tunnel. Class 8 trucks weigh more than 33,000 pounds and pull trailers from 28.5 to 53 feet long, and replicating their real-world operating conditions in a wind tunnel is difficult, and expensive even with scale models. CFD simulation can provide a more customized, reliable testing method in such cases.

In the past, companies like Navistar and other truck manufacturers used CFD during product design and development, but relied on wind tunnel testing to verify results. Under the new federal regulations, CFD simulation results alone can be used to certify a truck's compliance if the models is validated against established wind tunnel tests. That's a goal Navistar, together with Corvid and Intelligent Light, is driving to achieve.

Whatever the outcome of the certification process, the expanded use of CFD is having an impact throughout Navistar's development cycle and across the company's engineering teams.

Too much data, too little time – getting actionable data *fast*

Achieving the highest return on investment in CFD means reducing the cost and time of analysis while increasing output. In CFD simulation, results are king. Large, nonlinear, complex models translate into equally large and complex datasets. Buried in that mountain of data are the numbers, the insights, and the answers needed to make accurate, confident design decisions. When people are doing the work, there's often only enough time to post-process a small portion of CFD results – less than five



Top view with cutting planes at 30 and 60 inches from ground, 6-degrees yaw

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percent in some cases. That's not only a wasted investment, it means critical insights could easily be missed.

Implementing data management and automation tools makes it possible to not only increase output, but improve its quality and tailor it to project or company requirements. This approach enables engineering teams to interrogate a much larger percentage of solver results, reap significantly greater insight into the CFD performance of a design, and share those insights more effectively.

No matter how long or short a vehicle's design cycle is, a robust, agile workflow is essential to developing in-depth understanding and provides a solid foundation for innovation. Automotive manufacturers can easily leverage the proven workflows used in Formula One racing, where CFD is critical to achieving absolute performance and fast, accurate answers on a daily basis.

Generating and disseminating critical information automatically – every day

The pace of development doesn't run any faster than at Red Bull Racing, where its Formula One team has to add, change or tweak the design of its extremely high-performance race vehicles in tight time frames between racing weekends. Success at that pace demands the most streamlined, efficient CFD workflow – no rework or repetitive tasks, no time spent moving huge datasets, no waiting around for results and reports.

Nathan Sykes, CFD team leader, relies on CFD to investigate the impact of design changes on the car's aerodynamic performance. More than 80% of Red Bull Racing's aerodynamic design work is driven through CFD. With thousands of cores running concurrently, the team's compute requirements are massive, as are the resultant datasets. Using the scalable client-server architecture of FieldView post-processing, Red Bull engineers review data on their desktops, so data doesn't have to be moved.

Speeding the workflow without sacrificing accuracy or passing over a critical detail is made possible with automation. While post-processing can often require twice the time of a single solver run, nearly 90% of Red Bull Racing's post-processing tasks are automated via batch processing. The time this saves is immense, considering that Sykes' team is dealing with tens of car models, each made up of many hundreds of millions of cells, and changes are daily and constant.

Every morning, Red Bull engineers review the results of the previous night's runs, using automatically generated PDF reports. The reports, which can run to several hundred pages and include hundreds of animations, provide Sykes and his team clear insight into a myriad of

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characteristics: difference plots, turbulence effects, integrated forces, and more. Because of the time and effort saved with automation, the team can focus on extracting and exploring the most critical knowledge from the results.

Keys to Success

- Massive data doesn't have to be moved
- 90% of post-processing tasks are automated via batch processing
- Complete reports automatically generated overnight for next day review

The team is certainly doing something right – Red Bull Racing has claimed Formula 1's Driver and Constructor championships for three years running.

Keeping engineers focused on value-added engineering

In any engineering organization, people are the most critical investment. Reaping the benefits of their know-how and talent means keeping them focused on work that improves the final product and makes a difference to the end customer. This is especially true in consultancies where there is a high dependency on agile, productive workflows. In an effective CFD workflow, automation and data management free engineers and analysts from repetitive tasks, rework, and time wasted moving data around in order to focus on intrinsically human work.

Automation also enables the development of an organizational knowledge base that can be leveraged on future projects, further speeding the design process. As the knowledge base grows and best practices are captured, the company gains a solid foundation from which new employees can become productive fast.

Auto consultants depend on highly productive workflow to deliver timely, compelling results

Agility, speed, and insight – those are the keys to success at Corvid Technologies, an HPC computational analysis and engineering firm with customers in the automotive and defense industries. In order to present clients with useful, understandable results, the Corvid team has to work with a variety of CFD solver codes and other tools while managing hundreds of terabytes of data. Streamlining the workflow in this challenging environment is essential. Corvid's focus is on predictive solutions, using CFD to understand the 'why' behind test results. The traditional 'build – test – break' approach is time-consuming and costly, and in some cases impossible. Corvid takes a computational approach to narrowing down ideas, which compresses time and cost and gets closer to an optimal design from the start.

CFD's ability to help analysts understand changes in flow structures and identify the basic aerodynamic properties that cause those changes helps create a knowledge base that informs future projects. Although operating

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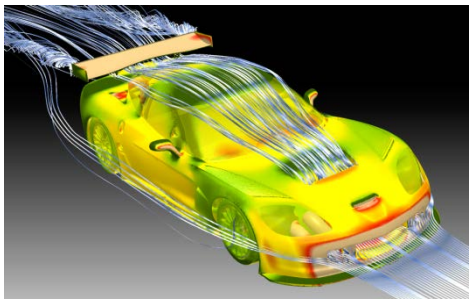
conditions for vehicles are obviously quite different than those for a missile or plane, "there is a lot of fundamental knowledge that goes into understanding how to put a CFD solution together," says Dr. Jimmy Carpenter, chief aerodynamicist at Corvid. "We are constantly learning, getting better at modeling, improving throughput. That knowledge carries over to inform future development projects."



With typical problem sizes running from 100M to 200M elements, Corvid's computing cluster is constantly humming. Taking advantage of parallel processing with FieldView, Corvid has significantly reduced post-processing time. A run that used to take upwards of 15 hours can now be completed in about an hour. For Corvid analysts working off-site with customers, FieldView's client-server architecture offers the crucial ability to work with results files remotely without having to move huge datasets.

The company also relies heavily on batch processing and automation, using FieldView to generate a series of cut planes on design alternatives, to produce images and animations, and to analyze data. The scripts are tailored to the specific project and evolve over time as the analysts learn more.

"Automation takes the analyst out of the loop," Carpenter says. "They aren't spending their time bringing up the model, turning it around, figuring out cut planes and streamlines. That is all automated in the background, and when the flow solver finishes it kicks off a post-processing job that runs through the scripts and produces reports, usually overnight so the reports are ready each morning. The analyst gets an email that the job is done, and they can pull up the results and get to work."

In the specialized world of engineering consultancies, success requires a flexible, robust, and highly efficient workflow – one that gets accurate results to the customer quickly, handles a variety of data formats and software tools consistently, and maximizes productivity while adding to the firm's knowledge base. Corvid Technologies has got that part of the equation solved.

Keys to Success

- Greater insights, deeper understanding build knowledge and confidence in CFD results
- Parallel processing cuts post-processing time to an hour
- Computational approach compresses time and cost, gets to optimal design faster and earlier

Summary

CFD is a complex domain, and essential to the design of automotive products. Today's high performance computing resources and specialized solver codes make it easy to churn out massive CFD datasets, but finding the needed answers in all that data requires accurate, reliable, flexible post-processing.

The key to success with CFD is in effectively post-processing results to gain critical insights and turn the data into decisions.

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A streamlined, efficient CFD workflow reaps significant benefits across the engineering environment, enabling greater understanding of design performance and expanding opportunities for collaboration and innovation, all while saving time and effort. That's a true competitive edge in meeting the many challenges of the modern automotive age.

Management Challenge:
Solving the Tools – People – Time Equation

Providing the right tools to the right people, at the right time, in order to get the job done right is a challenge every manager faces. Investments in hardware, software and personnel must provide a fast payoff in terms of increased productivity and successfully achieving project time, cost and design goals. Any changes to an existing workflow must add significant benefits, integrate smoothly, and minimize the learning curve for both current and new engineers, designers, and analysts.

In the complex world of CFD, the right tools can make all the difference in getting to the right answer at the right time. When it comes to the crucial phase of post-processing, FieldView from Intelligent Light is consistently praised for its ease of use, intuitiveness, and powerful performance. Read what some of our users say:

"I had not used FieldView prior to joining Corvid – I was one of those novices who had to learn from scratch. I sat down with FieldView my first day and was able to figure out how to pull up images, do couplings, streamlines – some of the basic stuff you want to do with a model. That may sound trivial, but in some of the other [post-processing] packages it's not really very straightforward.

I was able to be productive even while I was learning. Some other tools have a steep learning curve; it's hard to pick up and become proficient. FieldView is extremely intuitive. You can take a novice and get them up to speed relatively quickly.

That was our [Corvid's] biggest attraction to FieldView – the intuitiveness. The last thing you want is to have to spend time learning how to use the tool. I just want to *use* it."
Jimmy Carpenter, Ph. D., Corvid Technologies

"FieldView is one of the easiest packages to learn; it's very straightforward. There may be a lot of experience required to run the CFD solver code properly, but not a lot of experience is needed to look at the results. That's one of FieldView's strengths."
Navistar aerodynamics engineer

"FieldView is very fast and powerful, even for our largest post-processing problems, yet it's also self-explanatory; we can give a client a brief introduction and they can explore their data effectively. Even an occasional user can return to FieldView and use it well. You can't do that with any other tool."
David F. Robinson, Ph.D., President, Corvid Technologies

Formula 1 images courtesy of Red Bull Racing. Corvette and open wheel racecar images courtesy of Corvid Technologies. Truck simulation data provided by Corvid Technologies and Navistar International.

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