# LED Thermal Management Report:
## Predicting Thermal Issues Associated With High-Intensity Lighting

**HOW TO HARNESS THE POWER OF COMPUTER-AIDED ENGINEERING ON YOUR NEXT PROJECT**

## Executive Summary

The true business case for CAE (Computer Aided Engineering) is contingent on a company's ability to integrate this technology into the conceptual design phase of its current product development process. Ultimately, this means putting CAE into the hands of design engineers that may only have marginal experience with these technologies.

Recent breakthroughs by a few CAE software companies have given rise to this trend and created what is now aptly called the upfront CAE category. Upfront CAE is an entirely different branch of the CAE family tree and is by far the fasting growing sector within the world of CAD, CAE, and PLM. Many companies have invested in upfront CAE, but few have unlocked its potential to exponentially accelerate and economize product development and innovation.

This executive report delves into the common mistakes that companies have made with their inaugural investments in upfront CAE, and then offers recommendations that will help your company unlock the power of these technologies in the earliest stages of product development.

# Case in Point

Jim Hinkle manages the eight person engineering department at Selbank Lighting in Franklin, Tennessee. Selbank is a prominent manufacturer of high end commercial lighting systems. In 2002, Jim was asked to create a new line of LED based products to tap into the popularity of the green movement. The marketing asked Jim to get the line designed and ready for production in 12 months. Competitors were developing similar stystems and the first company to market was sure to win the majority of the business.

**"What went wrong... Why is Jim Hinkle updating his resume?"**

The biggest design issue for these LEDs was thermal dissipation. Fortunately, Selbank had an experienced PhD analyst on staff to perform detailed CFD (Computational Fluid Dynamics) thermal simulations. On average, his process required full production-ready definition and sixty days to complete each simulation. Hinkle didn't have that kind of time or definition and decided to handle the challenge with the good old "guess, test, & hope" method.

Nine months into the project, initial UL testing revealed that Hinkle's team had guessed wrong. Their LED downlight fixtures fell well outside acceptable temperature levels- despite the large rear facing heatsinks Hinkle's team had attached. The team took an additional five months to redesign the system and achieve UL certification. Unfortunately, a competitor's LED offering hit the market three months earlier.

Not one to repeat the same mistake, Hinkle started looking into new approaches to ensure success with future demanding projects. He noticed a number of industry journals reporting new "upfront" software packages better suited for his regular-duty engineering staff to perform faster thermal simulations with their existing CAD platform. Hinkle explored the available options and invested in a single, networked license of the top brand on the market. He picked an ambassador from the team, Harvey Simpson, to attend an intensive two day training course for the new software.

By mid 2004, business was back on track. Selbank had completed a string of bread-and-butter projects for happy customers. Then, the VP of Sales slapped a new RFQ on Hinkle's desk with a big smile. It was worth $10M if the project could be completed in nine months. A new modern art museum in Toronto wanted to invest custom, state-of-the-art lighting. The museum wanted to make a statement with energy efficient lights that could be employed artistically throughout the building.

Hinkle quickly mobilized his team to attack the opportunity. Eight months into the project, Selbank's lights were installed on the first two floors of the museum. Before the next 3 floors could be completed, the installers noticed that the lights were operating at dangerously high temperatures. Harvey Simpson was asked to use his CAD-friendly engineering analysis software to analyze the cause and propose solutions. The team estimated a six month project delay for redesign. The museum cancelled the remaining order and proceeded with another supplier.

What went wrong? Why didn't the investment in CAD-integrated CAE help Hinkle and Simpson address the thermal challenge? Why is Jim Hinkle updating his resume?

This story is a composite of many all-too-common situations. The names and places have been changed to protect the guilty. The mistakes leading up to Selbank's failure are extremely common across all industries and CAE categories.

## Learning from Selbank's Mistakes

**Buying a treadmill does not guarantee weight-loss.**

Failures on rushed, high-profile projects are often the catalyst for companies to investigate next-generation CAE solutions. There is a reactive need to fix an embarrassing problem. The investment in these new tools creates an immediate sense of relief and corrective action. Some managers liken the sensation to the feeling that an out of shape person might have right after purchasing an expensive treadmill: For a brief phase, the problem seems "cured" even before the first treatment.

Selbank conducted a thorough software search and invested in the best, most appropriate tool for their situation. The solution, however, was meant to be integral in their routine design process, empowering their regular-engineering staff. It should have been formally installed as an additional tool in the department toolbox- right alongside 3D CAD and Microsoft Excel.

Selbank's first mistake was to send a single engineer off to training. Upon return, Harvey was supposed to transfer his knowledge to the rest of the team. However, no time was officially allocated to that activity. Real life soon set in, and everyone got busy with their regular responsibilities. The upfront CFD tool was installed on only Harvey's computer. The rest of the team began to assume Harvey was their "go to" CFD guy… much like their previous PhD analyst, but with CAD skills. The next several projects did not have significant thermal issues, and Harvey never even developed his own skill.

When work on the museum project began, Harvey worked late a few evenings trying to get reacquainted with his upfront CFD software. The team had some early heatsink design ideas, but Harvey waited until he saw a reasonably detailed CAD model to begin his analysis. By the time he finished his first full simulation, the product had already gone through four major revisions to accommodate clearance issues at the museum. His work did not reflect the latest design. Harvey waited too late to get started and just couldn't keep pace with the process. The team had no choice but to move forward… and *hope*.

Selbank could have successfully implemented their upfront CAE tool with some easy process and philosophy adjustments. In this extreme case, the failure to quickly address thermal challenges cost Selbank $5M in sales.

The rest of this executive report will give you some insight into the best and worst practices associated with an Upfront CAE implementation.

## Why Invest in Upfront CAE?

For nearly 25 years, CFD and most of all CAE followed a single track comprised of complicated software tools built for highly trained, highly specialized users. Then in the mid-90s there was a divergence. The tree split into two major branches: Upfront and Traditional. Traditional tools and PhD level users are still required to handle a minority of complex research projects. Upfront CAE, however, has emerged as the simulation workhorse enabling engineering teams to attack the majority of live projects in today's shrinking art-to-part life cycles.

When introduced as a common tool to be used early and often, upfront CAE can quickly become a standard part of the engineering process. These tools allow engineers to quickly down-select through hundreds of design options in a qualitative way that is simply not possible with physical prototypes in the lab. As the best design directions emerge, the engineers can include more detail and move towards a more rigorous, quantitative simulation phase akin to traditional CAE. The real business benefit of upfront CAE, however, lies in the early phase. Unfortunately, this fact is often lost on new upfront CAE adopters.

**"Properly selecting upfront CAE tools is totally different than choosing traditional CAE tools."**

## Selecting an Upfront CAE tool: the first step to success or failure

The process of choosing an appropriate upfront CAE tool for your company should be totally different than the one used for traditional CAE solutions. Engineers and scientists who use traditional CAE tools *specialize* in driving them. They are paid to understand every aspect of the tool and underlying technology, will tolerate (and even enjoy) a far deeper level of training on the tools, and are far less sensitive to issues of ease-of-use. Only a few licenses of traditional CAE tools are typically required, so pricing is usually not the primary concern. The right tool is simply the one that most accurately solves all the possible physics requirements of your most difficult problems. Ease-of-use and cycle time are minimally important.

Since getting accurate, precise results is the primary goal with traditional simulation, it is best to first ensure that all physics are covered. Then let the actual users benchmark each tool in-house. Then down-select to a few potential vendors and procure fully-functioning evaluation licenses for each tool. Let your specialists master and run each over a lengthy period and let *them* make the final decision.

Unfortunately, many companies try to apply that same approach to selecting upfront CAE tools. Usually they end up choosing an inappropriate tool based on bad criteria and severely limit the chances of future success.

# Five Ways Companies Lose Momentum and Make Bad Decisions When Selecting CAE Tools for Design Engineers

1. CAE specialists in charge of the decision
2. Lack of clear executive support
3. Having the wrong goals
4. Using the wrong criteria
5. Multiple in-house evaluations

**"A specialist's choice will usually skew to a deeper set of features."**

### 1) CAE specialists in charge of the decision

Many companies looking into upfront CAE will call upon existing in-house specialists to choose the technology. Since these folks are CAE experts, they should be best suited to make good simulation decisions for the rest of the company, right?

Wrong. While they certainly have a wealth of knowledge on CAE technology these specialists are expert in a process that is much different than the one in which design engineers operate. The specialists are steeped in long R&D cycles and detailed, highly-accurate analyses. There is a real disconnect between the factors they perceive as important and the ones that will ultimately lead upfront users to accept a tool. A specialist's choice will usually skew to a deeper set of features (most of which will never be used by upfront engineers) and discount the importance of ease-of-use and CAD integration. Specialists do not typically use CAD tools and often fail to appreciate how vital they are to the daily experience of design engineers.

Additionally, specialists are often threatened by upfront simulation initiatives. Since CAE expertise is their identity, they are typically revolted by the idea of "regular engineers dabbling in simulation." Issues of job security and pride often collaborate to cloud their judgment.

A far more valuable approach is to empower the upfront engineers and their direct management chain to select an appropriate tool. The potential users and their leaders all have the same goals, outlook, and sensibilities. It is generally better to give the upfront team ownership of the decision.

### 2) Lack of clear executive support

Multi-tasking product design engineers need to know that their efforts are aligned with corporate initiatives and come with executive support. Though upfront CAE tools offer a huge return for the frontline engineering team, the investigation and selection process required to get these tools in-house can easily be seen as a distraction from their daily firefighting.

To successfully choose and implement upfront tools, it is critical that the potential end-users perceive clear executive leadership for the process. Rewarded actions are repeated actions. If the frontline engineers do not believe management will support and even reward upfront CAE implementation and usage, they will not invest any energy integrating it into their process.

### 3) Setting the wrong goals

Upfront CAE tools offer the biggest return when used during the conceptual design phase for dozens or hundreds of lightning fast "what-if" analyses. It is best to focus on comparative studies to quickly down-select design directions. During the software selection process, however, many companies become overly fixated on benchmarking for accuracy. The thinking, understandably, is that the best software for the job is the one delivering results that best correlate with a set of test data. That extreme focus on accuracy benchmarking wildly stretches the decision timeframe and often ends in a no-decision. Even if an investment is made, the upfront CAE initiative has already been tainted with the "single perfect analysis" philosophy from the very beginning.

Most decade-old CAE tools will achieve similar accuracies given proper setup. If accuracies within 0.1% are truly important to your particular product, then you should really be investigating a traditional CAE tool and looking for a specialist to drive it. The more critical goal for upfront CAE should be ease in setting up iterative design reviews. Focus on quick turnaround from concept to result. The process of changing CAD dimensions on-the-fly and quickly seeing the comparative effects should be among your most critical goals.

### 4) Using the wrong criteria

Selecting the right upfront CAE tool for your team is vital to your future success. More often than not, the selection process comes off the tracks because of poor criteria choices

#### *Price*

Many companies start the selection process focusing on functional and usage criteria but in the end simply go with the package featuring the "best price." If you are currently relying on "guess, test, and hope" in the lab, the return possible with upfront CAE will be many more times the cost of the software within a year. You will typically see a per license range within $5-$15k between the various vendors. Given the fact that a successful tool could save you $100-300k per year in R&D time, material costs, and labor, that range is inconsequential.

#### *CAD Association*

Associative CAD integration is one of the most important criteria to assess. Since your frontline engineers are already comfortable with 3D CAD tools, it is critical to offer them a solution that works with their native CAD assemblies. It should avoid data translation worries and maintenance of orphan CAE models. Upfront CAE software companies currently handle this requirement either by attempting to embed their solvers within the CAD user interface or by building a more stable external interface which communicates directly with the CAD tool. It is important to understand that both approaches can work very well or fail. Do not assume that an embedded solution is better than an integrated, companion solution.

#### *One stop shopping*

Some vendors offer one-stop-shop solutions for every genre of analysis (Stress/strain, computational fluid dynamics, electro-magnetics, etc). While it sounds like a good idea, it rarely leads to a best-in-class solution for any of the individual products.

**"Do not assume that an embedded solution is better than an integrated, companion solution."**

Most CAE tools started life focusing on a single area. The creators of these tools were bent on doing one thing and doing it extremely well. Most one-stop-shop tools are the product of corporate mergers and acquisitions. In many cases, the folks most passionate about the individual products were downsized or retired in the process. Software development and focused technical support for each individual product generally suffers.

**5) Excessive in-house evaluations**

Extensive in-house evaluations are hallowed traditions at companies with specialist, high-end CAE tools. Some *new* traditions are required to effectively and profitably select CAE tools for design engineers. The target end-users for these tools are extremely busy and will not expend the time for thorough evaluations. In truth, most 30 day software evaluations actually get started on day 29! Any comparative conclusions reached with these in-house evaluations are cosmetic at best, and haphazard at worst. It takes time and energy to successfully inject an upfront CAE tool into the DNA of a frontline engineering team. It is impossible for these folks to predict what would be most important to their sustained usage of such a tool through a preliminary kicking of the tires. Excessive in-house evaluations also tend to slow momentum and delay or prevent the return expected with an actual implementation.

**"In truth, most 30 day software evaluations actually get started on day 29!"**

## A Pragmatic and Proven Evaluation Process

Much of your future success with upfront CAE will be based on your attitude and behavior during the selection process. Choose wisely with the right people, criteria, and purpose. With those in place, the following process (while non-traditional) is proven to most efficiently deliver success::

1. Identify a current project where simulation guidance would add meaningful value.
2. Down-select to a couple of solution vendors.
3. Invite the vendors in for live demonstrations with the group.
4. If the decision is unclear, supply all vendors with real CAD models and invite them back in for live, detailed, "soup to nuts" demonstrations of the simulation process.
5. Arrange for a training session and have the vendor help students get hands-on experience with generating a design review. Their real mastery of the technology will only happen after an investment in software has been made and a few real projects have been tackled.
6. If necessary, contract the vendor to complete the current project as an outsourced service. Agree upfront to include a "technology transfer" of the project to your team during your training and implementation phase.

# Implementing Upfront Simulation Tools

After choosing and procuring an upfront CAE tool, many companies expect it to magically be used and generate an ROI. Without a well conceived implementation plan, however, even the easiest of tools will soon gather dust on a cubicle shelf.

**"The value of upfront CAE is totally missed when the tools are used for design verification."**

## Six Imperatives in Rolling Out CAE to Design Engineers

1. Maintain clear leadership support
2. Provide adequate training
3. Beware the Non-Specialist Specialist
4. Tap into vendor expertise
5. Build upfront CAE into your official process
6. Forget one. Focus on many.

### 1) Maintain clear leadership support

To get the most out of upfront CAE, engineering leaders and executives must create an ongoing atmosphere to support usage. The smallest recognition of a success will quickly embed this technology into the DNA of the organization. It is critical for company leaders to insist upon and reward upfront simulation techniques… or the team will soon return to inefficient lab testing, outsourcing, and guessing.

### 2) Provide adequate training

Sounds obvious, but this is a simple and correctable mistake that many companies make when rolling out upfront CAE. These tools are heavily sold on ease-of-use, and companies often equate that with "no training required." Imagine if the same thought process had been applied to your 3D CAD tool. It is important to officially train all the engineers who may need to use these tools. Since upfront CAE is often sporadically used, it can be extremely productive to provide a schedule of touch-up training every 6 to 12 months.

### 3) Beware the Non-Specialist Specialist

Upfront technologies provide the best benefit when implemented throughout the engineering team. Besides avoiding the obvious risk of "expertise walking out the door", a thorough implementation will enhance the entire group's efficiency and innovation. The cumulative effect will reinforce a regular cycle of usage and success.

Many companies specifically identify a single design engineer to shoulder all upfront CAE responsibilities. Others train the entire team and wait for individuals to show an interest. The result is usually the same in both cases: A single member of the design team gets targeted as the group specialist. That creates the same timing bottlenecks inherent with traditional PhD analysts and severely limits the impact of an upfront CAE solution.

### 4) Tap into vendor expertise

The software vendor can help in several ways. At the lowest level, simply make sure your engineering team takes advantage of all available phone, email, and web-based technical support. It is surprising how many new upfront CAE users do not even know what telephone numbers to call for support.

At a higher level, it is a great idea to bring your vendor in-house to collaborate on early, high-profile projects. Instead of simply outsourcing the work, an investment in such collaborative projects will build internal confidence and expertise.

Most vendors have experience with many companies inside and outside your industry. If you will share your goals and challenges, they can often suggest creative solutions that you would otherwise have missed.

**5) Build upfront CAE into your official process**

Neglecting to officially schedule time for upfront activities in your official process is a sure way to maintain "business as usual." If you typically track and manage projects with Gantt charts and gate review systems, be sure to specifically build upfront CAE milestones into the plan.

**6) Forget *one*. Focus on *many*.**

Upfront CAE tools are best used to evaluate many design options at the conceptual stages. When integrated with parametric CAD tools, upfront CAE allows engineers to perform numerous what-if studies with very little project definition. Dozens or hundreds of potential directions can be compared to quickly choose the right places to focus engineering effort.

That central idea of upfront CAE is often missed by new adopters. The team waits to use the upfront design tool until the late design stages, after most decisions have already made. The tool ends up being used for *design verification* instead of *design direction* and has little impact on the overall project timeline or innovation. This is the single biggest factor in successfully rolling out upfront CAE technology. Upfront CAE is about doing more now… and less later.

## Profiting from the Upfront CAE Imperative

Existing upfront CAE technologies are proven, effective design tools in the Lighting industry. They enable regular, multi-purpose engineers to head off stress, strain, vibration, thermal, and fluid flow challenges in the earliest design phases. They are best applied as a pervasive core competency throughout design and engineering departments, rather than bottlenecked in the hands of a few specialists.

A well-advised next step is to investigate technologies like upfront CFD and FEA to provide your business with a short-term competitive advantage and assurance of long-term survival.

## About Blue Ridge Numerics, Inc

Blue Ridge Numerics, Inc. is the leading provider of fluid flow and thermal simulation tools for mechanical engineers. Its upfront CFD tool, CFdesign, was the first built from the ground up for multi-tasking design engineers. With recent recognition from Inc 500 and Deloitte & Touche as one of the fastest-growing private companies in America, Blue Ridge Numerics continues to alter the way CFD is deployed in top companies around the world. Please see www.cfdesign.com for details.

## About the Author

Jeff Waters began his engineering career at General Motors, where he introduced a variety of specialty and early CAE technologies for simulation-based stress, strain, thermal, and flow R&D. In 1999, Waters joined Blue Ridge Numerics, Inc. to help manufacturing and product development companies efficiently implement upfront CFD. Waters is a graduate of Rose-Hulman Institute of Technology. He can be reached at jeff.waters@cfdesign.com.


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