# How to Run a CFD Project

Computational Fluid Dynamics (CFD) - it beckons with the allure of extraordinary results, at a price far below typical experimental methods. CFD uses computer simulations to provide customized solutions on a wide array of fluid flow scenarios. However, CFD comes with a large risk of budget and schedule overruns. When careful project management mitigates these risks, CFD delivers on the promise of extensive knowledge at reasonable costs. Here are some recommendations on how to manage a CFD project and achieve the best experience possible when partnering with an experienced CFD service provider.

## Where to Use CFD

CFD is a maturing technology that allows engineers to understand interactions with air, water or any fluid. As a general rule, this tool has vast potential to answer any fluid question. This includes several possibilities such as:

- Visualizations of flow around docks and ships
- Pressure distributions for optimization of hull structures
- Force breakdowns for each structure on a rig
- Temperature and heat transfer analysis (to determine insulation needs or required steel grades)
- Resident time of air for HVAC analysis (greater crew comfort)

CFD works best when used as a bridge between analytical methods and experimental testing. This makes it ideal for design optimization or investigating multiple scenarios. Table 1 compares CFD to other methods used for fluid analysis. In some cases, CFD may even replace experimental methods at a significant cost savings.

The best way to start with CFD: locate a CFD service provider, discuss your typical projects and background, and ask the provider for recommendations on potential applications. It costs nothing to ask for more information.

Table 1: Where CFD Fits In

| | Analytical Methods | CFD | Experimental Methods |
|---|---|---|---|
| Project Schedule (relative time scale) | **Days** Analytical methods are normally very quick calculations | **Weeks** CFD requires extensive time for a single operator to prepare a model and numerous computing hours to solve the model | **Days** Multiple people can work simultaneously to create a model. The physical testing can happen within a period of days |
| Project Cost | $ | $$-$$$ | $$$$ |
| Accuracy of Results (margin for error) | +/- 15% - 25% | +/- 0.5% – 10% More accuracy requires more computation and larger budget | +/- 0.5% - 2% |
| Project Base Cost | $ Very little cost required | $$$$ Cost to build computer model and verify accuracy | $$$$ Cost to build physical model |
| Cost for Additional Design Points | $ Usually just a repeat of previous calculations | $ Mostly just computing cost | $$ High cost for additional use of experimental facilities |
| Cost for Additional Information/Details of Small Scale Features | N/A Typically, analytical methods are only accurate for global information | $ Once the computer calculates raw data, additional information is inexpensive | $$$$ Each additional piece of information requires more sensors and more experiment runs |

All numbers provided are heuristic guidance, based on the author's experience.

## Selecting CFD Providers

An experienced CFD service provider is the best solution to mitigate the risks of a CFD project and deliver the desired cost savings. But not all CFD providers are equal in experience or technical ability. A good CFD provider must have a sound technical background, good quality standards and experience specific to your application area.

> **"A good CFD provider will actively work to limit the scope and cost of your CFD project."**

A sound technical background makes for efficient CFD projects. This comes both in academic background and in previous work with CFD. Merely owning software does not guarantee that a CFD provider knows how to use it correctly. Colorful pictures of flow patterns do not prove expertise.

Instead, ask for examples of validation studies, including test cases where the CFD provider has compared simulations to actual experimental results. Validation studies serve as accreditation and demonstrate that the CFD provider can obtain results of reasonable quality.

Quality standards are another key element when selecting a CFD provider. Ask the provider what level of accuracy is expected on the simulation. All CFD simulations contain some level of inaccuracy, but a quality provider can estimate the

precise range of uncertainty. This awareness allows the provider to minimize project risk.

Mitigating risk also requires experience with your specific application. CFD is about more than abstract numbers. Seek someone whose knowledge extends into your industry and who can anticipate your needs. A good CFD provider should ask detailed questions about your situation and exactly how you plan to use the results in order to understand the limits of your application and tailor the simulation to target your desired goals. In fact, a good CFD provider will actively work to limit the scope and cost of your CFD project.

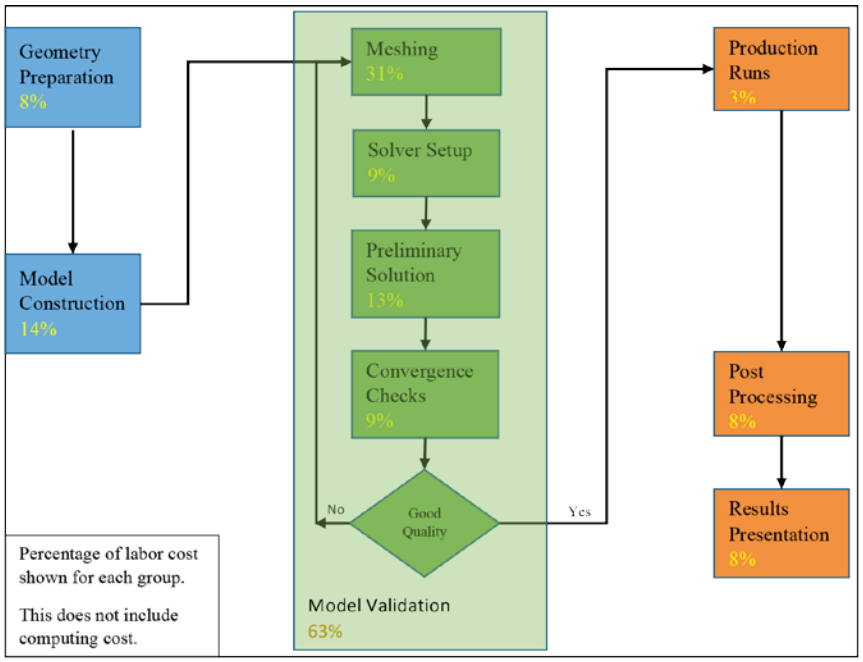



Figure 1: Typical Workflow for CFD Project

## Managing A CFD Project

Selecting a good CFD provider helps limit project risk, but attentive project management is also necessary to maintain that low risk. A CFD project flows through several stages. (Figure 1)

Figure 1: Typical Workflow for CFD Project

The best projects occur when you cultivate partnerships with a CFD consultant. Allow your consultant to understand the context of your project. Clearly establish expectations for schedule, results priorities and desired margin of error in outputs. A good consultant uses that information to insulate you from the project risks. The better a CFD provider understands your needs, the quicker they flow through the project and provide results.

## Geometry Preparation

The CFD provider builds the geometry for the object using 3D CAD software. CFD usually requires very high quality 3D CAD models. Almost all CAD models require some level of rework to achieve this standard.

## Model Construction

The provider imports the CAD geometry, adds physics models and specifies any environmental settings to match your scenario. At this point, the consultant searches for opportunities to simplify the model, which reduces computing cost.

## Model Validation

Model validation poses the largest risk in the project. The CFD consultant creates an initial setup and then tests that setup to ensure the simulation is stable and converges to a realistic solution. This is an iterative process, searching to balance the desire for minimal computing costs with the need for simulation accuracy. At the end of the validation process, the provider will conduct a series of convergence checks, also called a mesh independence study. These checks establish the simulation's margin of error. Once the provider is satisfied, the client should perform a preliminary review. This review is one last chance to confirm final settings and desired outputs for the production runs.

## Production Runs

The CFD provider progresses through all the simulation conditions requested by the client to extract all the desired results. This stage incurs large computing costs, but relatively little labor. This is when the CFD provider can begin to provide reliable data for use by the client.

## Post Processing

At this point, the CFD provider reviews the results and converts the raw data into formats that allow easier interpretation. Typical outputs will include tables of numbers for the specific data requested. The provider will also include several images to visualize interesting details about the simulation and explain the reason for any unexpected answers.

## Results Presentation

At the final stage, the CFD provider organizes everything into a concise presentation, usually in report form. This report contains all the outputs, simulation visuals and information on model

validation. The report should also include enough detail about the simulation setup so that a third party could reproduce the simulation, if desired.

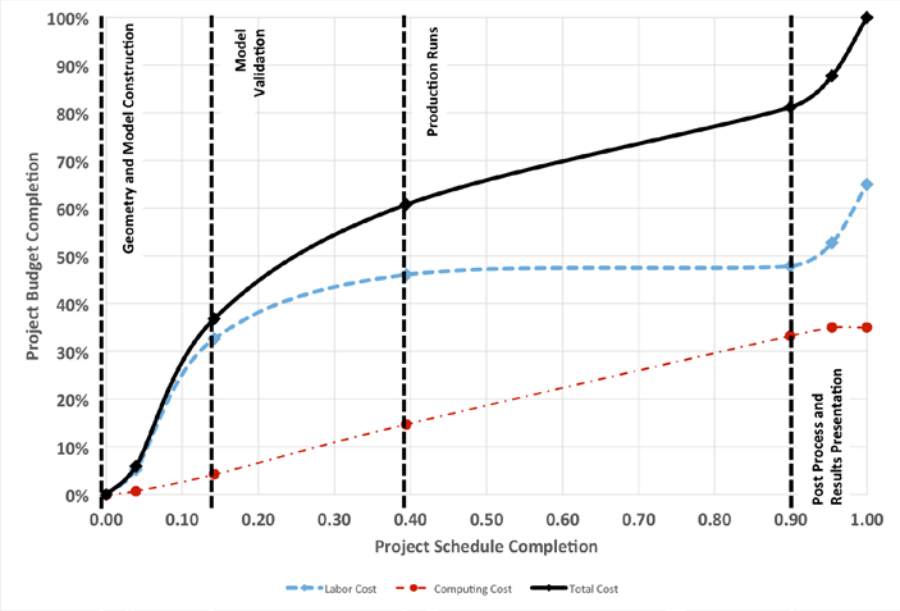
## CFD Cost Centers

Just like experimental testing, CFD projects include several cost centers. Failure to recognize these cost centers leads to unexpected cost overruns and projects can quickly go over budget. The three main cost centers for any CFD project are:

- Hardware costs
- Software costs
- Labor costs

Hardware combined with software constitute a significant part of the budget in any CFD project. Figure 2 shows the budget expenditure for a typical CFD project. The combined cost of hardware and software (computing costs) are around 35% of the total project cost, and should be managed carefully together with the labor cost.

The labor cost for a CFD project is largely front-loaded. Most of the labor is expended during model construction and validation.




After that, the computing costs dominate during production runs. A responsible CFD provider recognizes that these costs vary at each stage of the project and monitors them closely to ensure the project remains on schedule and within budget.

## Conclusion

When done well, CFD offers customized results at a reasonable cost. It gives the client the option to customize the budget, the desired results and the project schedule. Now the client can ask specific questions and obtain detailed answers, often at a lower cost than experimental methods. This evokes possibilities of using CFD in design optimization, preliminary testing and even detailed design. CFD provides a smooth accumulation of knowledge as your projects and designs progress. With thoughtful project management, CFD truly delivers the best of both analytical and experimental methods.

**Click here to access the ACMA website.**