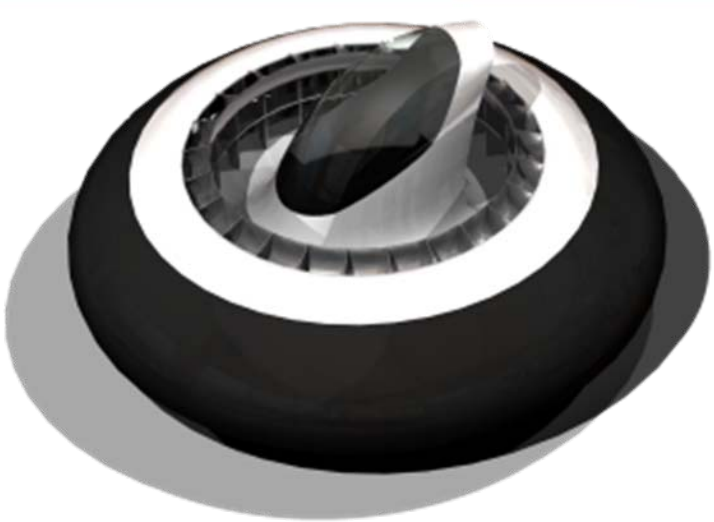
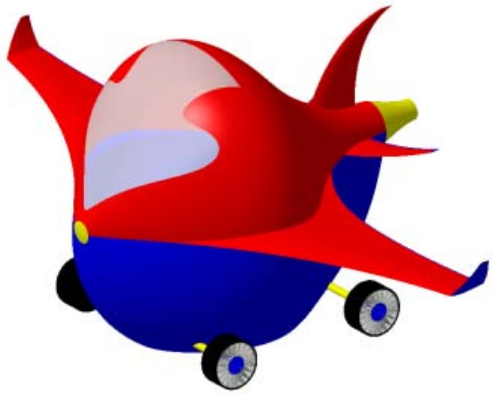
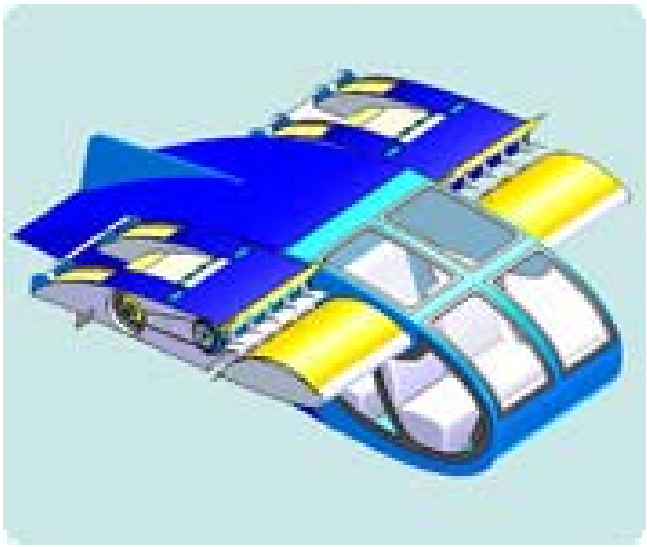
CD-adapco

NAFEMS 2040

North American Future of Engineering Methods Symposium







The PLASVEE Challenge:

Developing a Personal Land, Air, and Sea Vehicle in the Year 2020

Dr. Dennis Nagy, “Former” VP, Marketing & Business Development

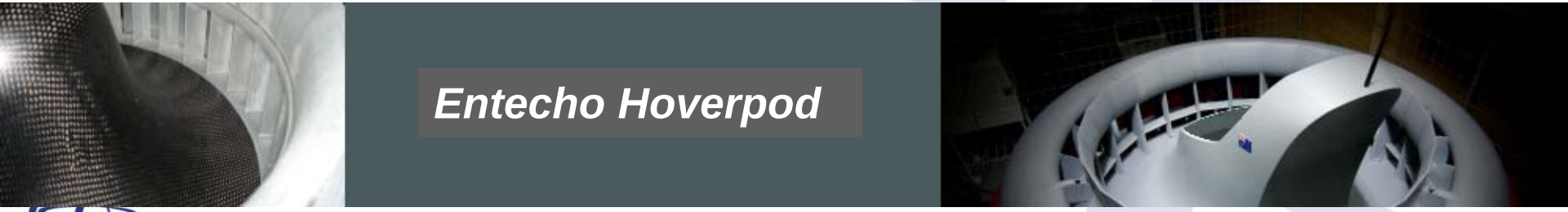
October 20, 2020

Agenda

- Thanks to organizers for their enduring vision
- Who “was” CD-adapco?
- The PLASVEE Challenge
  - History
  - Current status
- The multiple facets of virtually engineering a PLASVEE in 2020
  - Modeling the concepts
  - Simulation (multi)physics
  - Engineers and their environments
  - In the (“transparent”) background:
    - Numerical methods
    - Computing hardware resources
    - Data management

Thanks to the PLASVEE Challenge Organizers

- Thanks to Rod Dreisbach, John Vandevnter, and Lee Krueger of the Seattle super-company ***MicrosoftBoeing***
  - Started the PLASVEE Challenge in 2008
  - Institutionalized it as a biannual NAFEMS event
  - Made it ***virtual*** since 2014 (WebEx ConferenceCenter 3D, powered by 3DVIA+ from ***Oracle-DS***)
  - Suggested that this 7th PLASVEE Challenge Roundtable be a ***physical*** (rather than virtual) one, for ***nostalgia*** reasons, so…
- … I actually arrived here in Hampton, VA in my 2015 first edition collector model of Entecho's Hoverpod "PLAVEE" (more commonly known as a PAV=Personal Aerial Vehicle)



Who “was” CD-adapco?

(status 2008)

A ***Full Spectrum*** Provider of Computer-Aided Engineering (CAE):

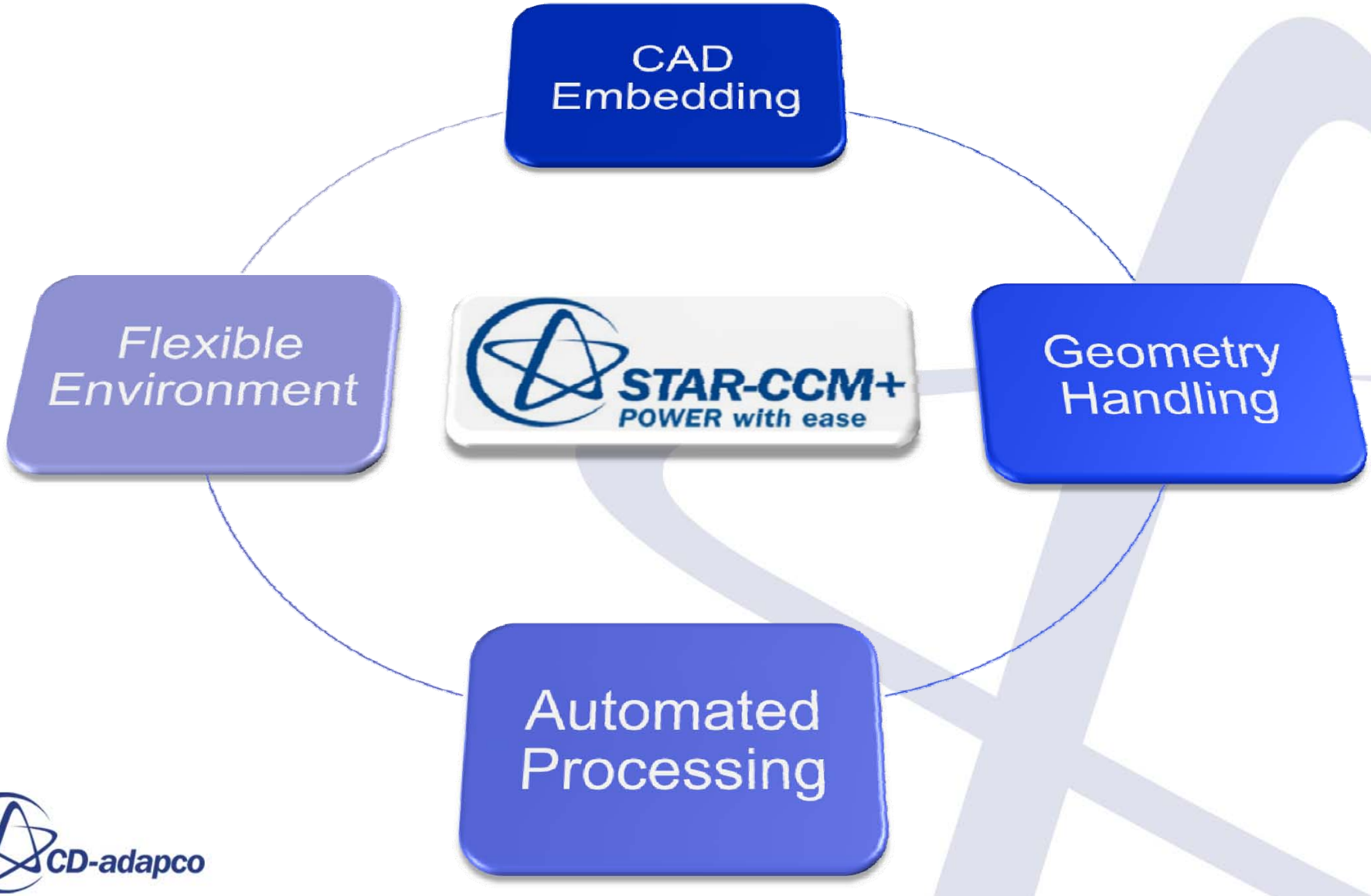
- Flow, Thermal and Structural expertise
- Research and Engineering Services
- Industry-leading CFD Software Solutions (The ***STAR*** Family)
- Founded in 1980 in Melville, NY, by Steve MacDonald and Bill Wheeler
- Approximately 9,000 Users of our software worldwide in 2008
- Global End-user Spend on CD-adapco Software and Services Exceeded $90M per year in 2008 (20%+ Growth Rate and 20%+ Revenue in Consulting Services)
- 500+ Employees
- **Acquired in 2015 by….*but then you all know by whom!***

Main Centers in New York, London and Yokohama

The PLASVEE Challenge

- Inaugural event in 2008 revealed that much of the simulation technology for engineering a PLASVEE was ***already in place***
- Small entrepreneurial companies were already developing prototype “PLAVEEs” (=PAVs) and PSVEEs (= PSVs) using state-of-the-art (2008) simulation solutions
- A few PAVs have actually made it to market in ~2015 as certified land/air vehicles, mainly because the governments have developed and instituted the necessary Personal Air Traffic Control Systems (based on NASA research)
- We are now (in 2020) addressing how to move to the “second generation” by adding in the “**S**” (**s**ubsea-worthy PAVs) using the latest technology and virtual engineering environments available to us…

2008: PLASVEE-Necessary Simulation Technology Already in Place... e.g. Flow, Thermal and Stress Simulation in One Integrated Environment

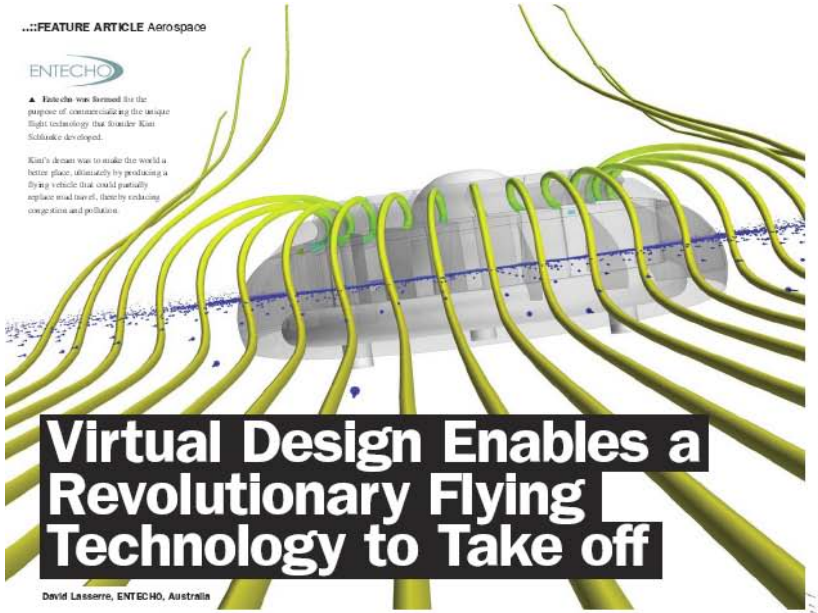


A PLAVEE Prototype ca. 2008 from Entecho
(Perth, Australia)

ENTECHO

▲ Entecho was formed for the purpose of commercialising the unique flight technology that founder Kim Schlunke developed.

Kim's dream was to make the world a better place, ultimately by producing a flying vehicle that could partially replace road travel, thereby reducing congestion and pollution.



Virtual Design Enables a Revolutionary Flying Technology to Take off

David Lasserre, ENTECHO, Australia

The challenge of designing a next generation compact Vertical Take Off and Landing (VTOL) craft has been addressed with the combination of a novel radial fan technology and the use of unique lifting and control surfaces.

▲ Fig:01
Using an axis symmetric mesh provides the best compromise of quality, density and size

CFD Techniques

The design process started with a searching aerodynamic analysis in order to establish the best interaction between the lifting surfaces and to set the parameters of the propulsion system that satisfy the lift requirements. During the concept creation stage, no prototype was built, and the geometry development relied only on the CFD results. To ensure a high turnover of results for each configuration, automation scripts were written to create, mesh and run a matrix of geometries and boundary conditions.

In the next step where the flight mechanics and stability are analyzed, all surfaces relevant to the control of the craft are modeled in detail. However, to reduce the complexity, rotor and stator blades are simulated through a momentum generator, using the user subroutines capability of STAR-CCM+. The radial momentum added to the system converges on the value of the power input needed to hover in each case. An additional swirl can also be added to accurately simulate any residual tangential flow.

The mesh generation and model setup is controlled by a script that implements the CDadapco automatic meshing feature when running a series of cases at different control surface configurations and flight orientations.

The flight control system analysis has proved essential in the optimization of the performance of the attitude control system. For example, the flight performance of the manned platform in particular required detailed analysis of its behavior in ground effect. This flight control system analysis returns accurate aerodynamic forces and pitch, roll and yaw torque inputs to the flight controls system lookup tables, with up to four configurations being run daily on the solving cluster.

Simultaneously, the propulsion system and lifting surfaces are analyzed in greater detail. Sector meshes are set up for the Moving Reference Frame (MFR) method to analyze the propulsion turbo machinery. Special attention is paid to the rotor and stator interactions with the blades optimized to satisfy the dual requirements of efficient lift generation and rotor torque cancellation.

During the same design loop, the yaw control surfaces capabilities can be evaluated in order to complete the range of information needed for the flight controls systems. Mesh size and setup parameters have been optimized to allow at least one configuration to be run overnight. This stage closes the aerodynamic design loop, as shape and dynamic loads are then known for the CAD/FEM team to finalize the model.

Benefits and Achievements

The STAR-CCM+ simulation process is fully integrated into the virtual design process and interacts strongly with the CAD design and software development for the control system. The design loads predicted by the CFD analysis make the choice of the composite materials in the craft's structure much easier, leading to significant weight reductions and further improvements in the payload and endurance capabilities of the flight platform.

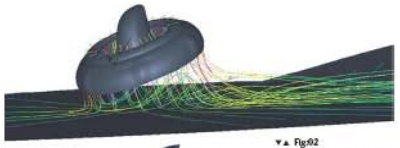
The flight control system CFD analysis has proven to be a powerful tool. One of its most important outputs is the data that is fed into a flight simulator that delivers realistic attitude response and lift characteristics. It has also made it possible to identify, quantify and address an unusual ground effect response and therefore avoided putting the prototype craft or personnel at risk.

Once the CFD calculations of aerodynamic performance and attitude control met the prerequisite targets, a prototype flight platform was constructed.

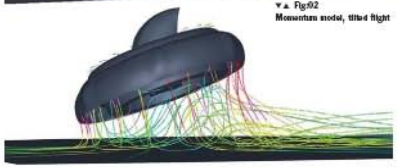
The successful test flights of this "MuPed" UAV (unmanned aerial vehicle) has confirmed the value of CDadapco products in providing accurate flight characteristics early in the development process. It was very rewarding to witness the technology at work as the prototype took off for the first time and behaved as predicted by the flight simulator.

Evolution

The virtual design environment approach has provided an early and thorough understanding of the potential and capabilities of this innovative flight technology. The number of hardware variants selected for construction has been reduced significantly by using the right tools and the right techniques and significant savings in time and cost have been realized as a result. We are currently updating the implementation methodology to use STAR-CCM+ with very promising results so far. ■

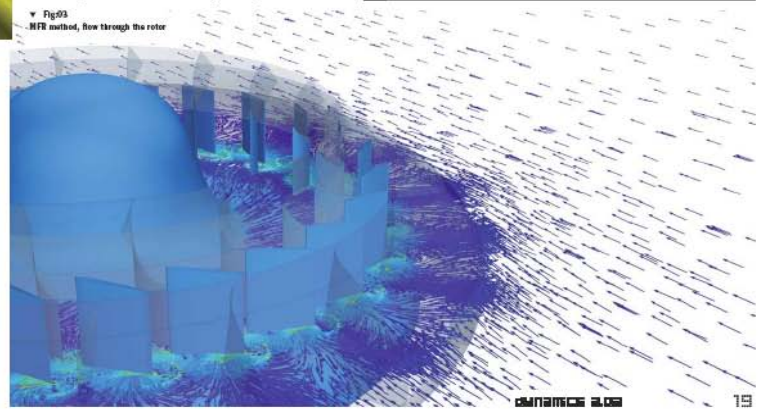


▼▲ Fig:02
Momentum model, tilted flight

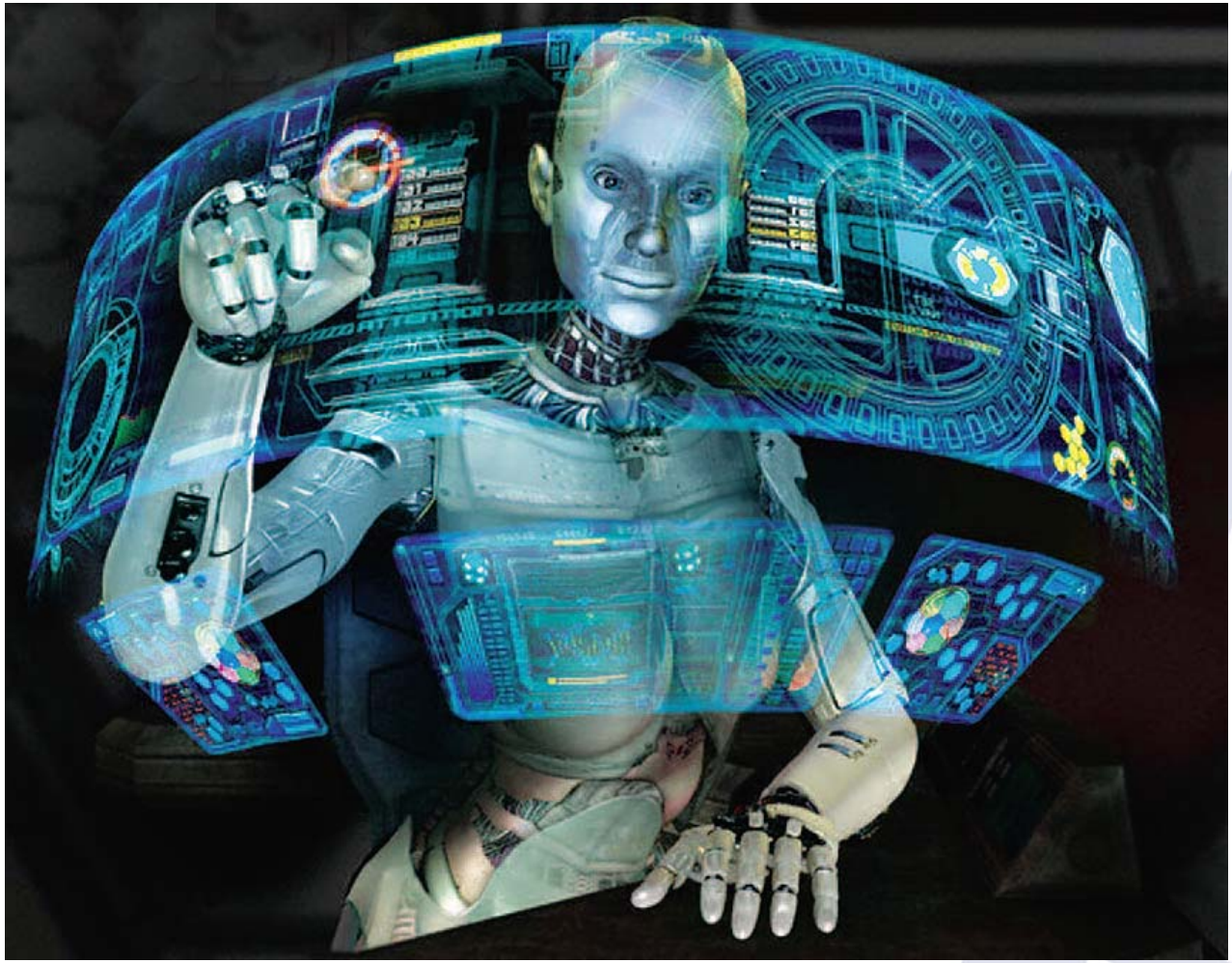


ⓘ MORE INFORMATION http://www.entecho.com.au

▼ Fig:03
MFR method, flow through the rotor



So, now in 2020:
Can We Just Ask Our Robot Engineer to Push a Button?

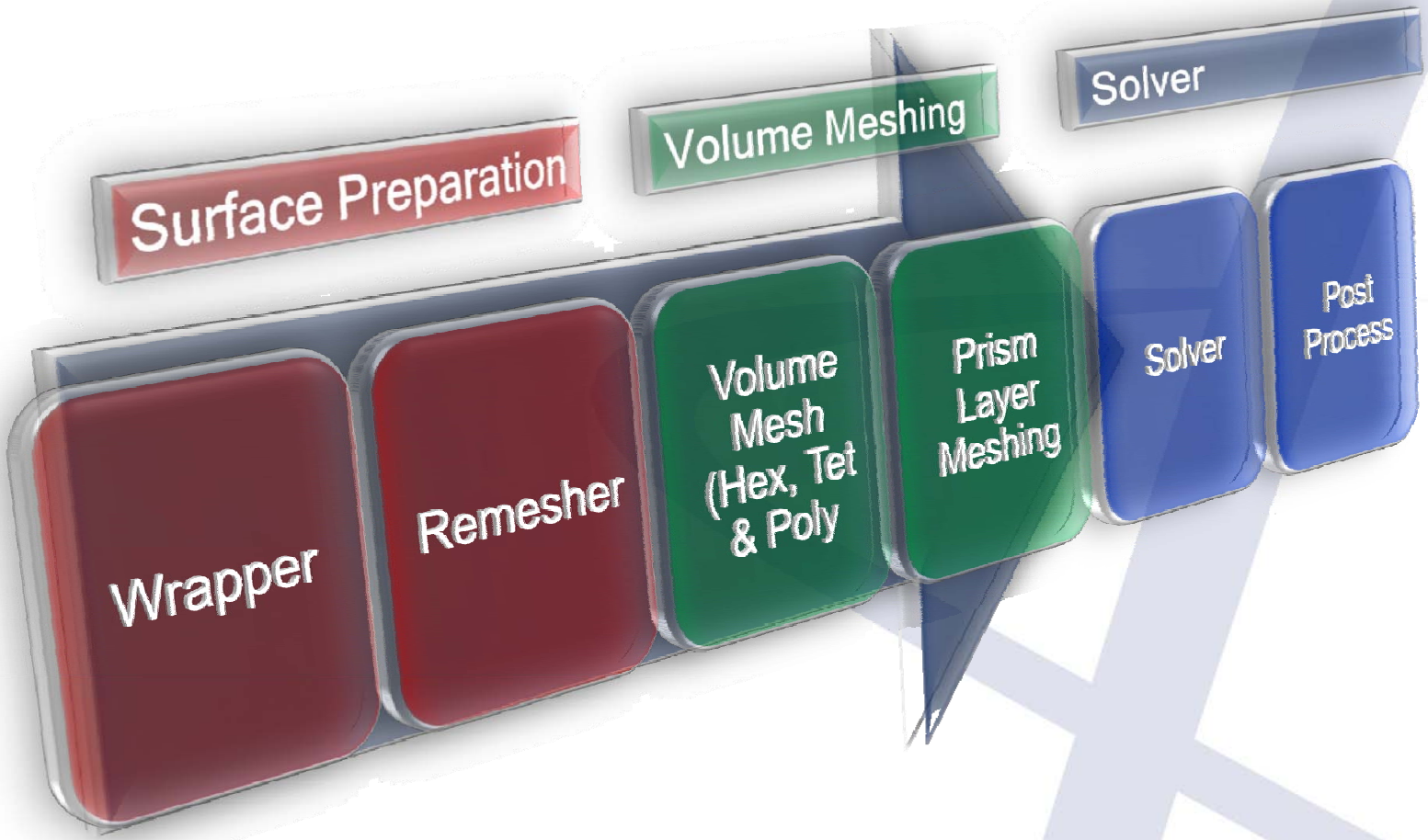


Virtually Engineering (via Simulation =CAE) a PLASVEE-1

- 1. Modeling the concepts
  - ***Evolutionary*** progress between 2008 and 2020 in much more transparently doing multi-physics simulation upon "native" (product development engineer-created) sets of geometry
    - » Automated surface wrapping/healing of multiple-source geometric info.
    - » Automated, adaptive meshing as basis for FEM & FVM-based simulation solutions
    - » Great progress in unifying the modeling geometry with the simulation geometry (e.g. Tom Hughes 2008 NAFEMS 2020 Keynote) –the main "***breakthrough***" technology

2008: From CAD/Assembly Geometry to Flow/Thermal/Stress Simulation Solutions

- Ease-of-use & Quick Turn-around Time
  - Automation: The “Meshing Pipeline”



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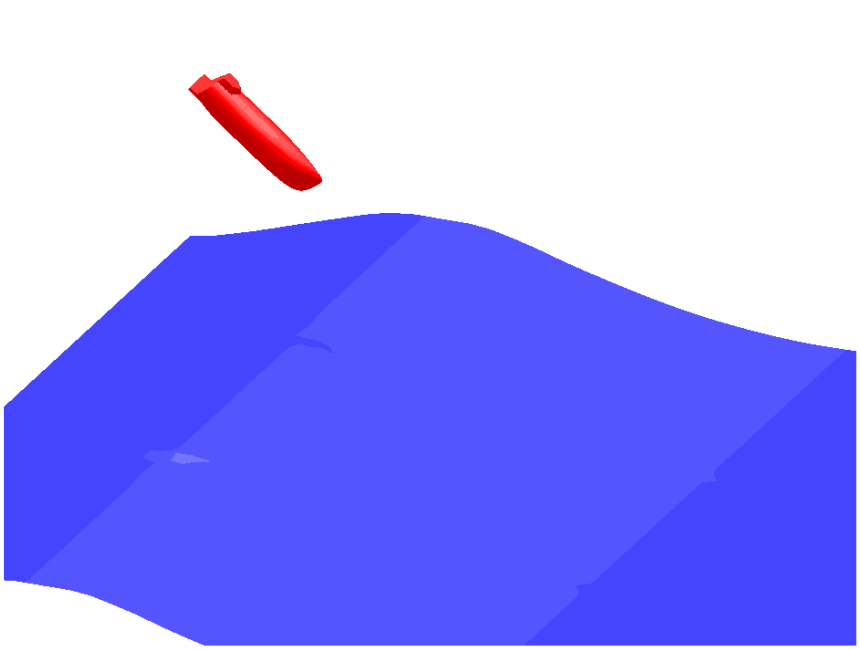
Virtually Engineering (via Simulation =CAE) a PLASVEE-2

- 2. Simulation (multi)physics:
  - The methods and features to simulate PLASVEE behavior were **already** "in-place" in many 2008-vintage commercial CAE tools, *just not recognized/used enough*
    - » e.g., in the CFD/thermal arena (CD-adapco's focus):
      - Multiphase flow, conjugate heat transfer, accurate free surface (VOF), dynamic fluid-body interaction (DFBI) (ref. Entecho article)
      - Capable of accurately simulating external aero/hydrodynamics, engine fuel flow/combustion, engine cooling, passenger comfort, fuel-cell behavior, submersion and resurfacing
- Progress in these areas has been ***steady and evolutionary*** since 2008
  - Improvement of algorithms, especially ***synergistically*** with computing hardware advances (more later)
  - Continued correlation/validation with physical test data

Accurate Simulation of Submersion and Resurfacing Maneuvers (ca. 2008)



Virtually Engineering (via Simulation =CAE) a PLASVEE in 2020 – 1

- Engineers and their working environments:
  - ***Biggest*** progress here since 2008
  - …but still ***federated*** "best in class" simulation tools trump "unified ***single-supplier*** environment" to get the best answers in the fastest wall-clock/calendar time ***("Time to insight")***
  - Progress in related fields of virtual collaboration/telecommuting, transparent data management, and transparent "cloud" HPC have all led to product-development engineers
    - » being able to do their own simulations as an integral part of their product development responsibilities (and only consult the CAE specialist gurus/on-line help occasionally)
    - » Work/collaborate from anywhere (telecommute) and thus
    - » concentrate more on creative/innovative ideas and insight, instead of being computer and meshing "jocks"

Computer and Meshing Jocks Have Been Replaced…

Virtually Engineering (via Simulation =CAE) a PLASVEE in 2020 - 2

- In the (ever more “transparent”) background:
  - Numerical methods:
    - Steady progress, in strong synergy with hardware advances
    - Real use of smooth, automated co-simulation
    - Recognition and use of stochastic/probabilistic/”possibilistic” methods
    - Incorporation of materials engineering
  - Computing hardware resources
    - Always faster processors, but more importantly…
    - Much larger clusters, HPC-oriented mass storage, Clouds (clusters of clusters)
    - 3-D visualization, “PIE” (Personal Immersive Environments)
  - Data and engineering process management
    - Simulation Data Management coupled with ***Federated*** Application Access
    - **Federated** means engineers are free to choose (or have recommended to them) the best relevant application module, running on the best available hardware configuration “somewhere” (they don’t and shouldn’t care), in each and any engineering process environment they happen (or are required) to be in.

Summary

- PLA**S**VEE Second Generation is now being engineered in 2020 much faster (calendar time) but not with any ***fundamentally*** different underlying numerical methods than were available already in 2008.
- The main improvements enabling this statement are in the areas of
  - Engineering process automation
  - Simulation data management/re-use
  - Computer hardware networking concepts
  - 3-D visualization “immersive” environments
  - Stochastic/probabilistic/possibilistic simulation to take into account real-world variability

Thank you!