AFT Fathom™ and AFT Arrow™ Guide Rocket Design at KETEMA: A Retrospective

CASE STUDY

Pressurization, Propellent and Thruster Control System
Aerospace

Senior Aerospace Ketema
El Cajon, CA USA

You don't have to be a rocket engineer to use AFT Fathom or AFT Arrow... unless your job is rocket engineering. KETEMA designs systems for re-usable and expendable launch vehicles (ELV's), today's formal term for rockets. The design of fluid and thermal aspects of the ELV systems at KETEMA is the responsibility of Ichi Wakabayashi, Senior Mechanical Engineer. He chose AFT Fathom 2 and AFT Arrow 1 to help his group model the many fluid systems aboard an ELV.

Some of the reasons Wakabayashi cited for choosing AFT software were ease of use and the extensive database of fluid properties and component loss coefficients. *Since the release of this case study, AFT has implemented three other fluid databases, the Chempak database, NIST REFPROP, and ASME Steam/Water tables. Both Chempak and NIST REFPROP allow for mixtures and dynamic mixing in Arrow.*

Unruly analysis by hand, or spreadsheets, is still one of the common reasons AFT users rely on software. Especially as system complexity grows with branching networks, heat transfer, and compressibility, it is harder and harder to be confident in hand calculations or spreadsheet alternatives.

"Previously, analyses were done by hand, which was tedious and time consuming", Ichi said. "AFT [software] allows a repeatable tool for flow analysis that allows faster modeling of systems...with good graphical and tabulated outputs." *Unruly analysis by hand, or more commonly now with spreadsheets, is still one of the common reasons AFT users rely on software. Especially as system complexity grows with branching networks, heat transfer, and compressibility, it is harder and harder to be confident in hand calculations or spreadsheet alternatives.*

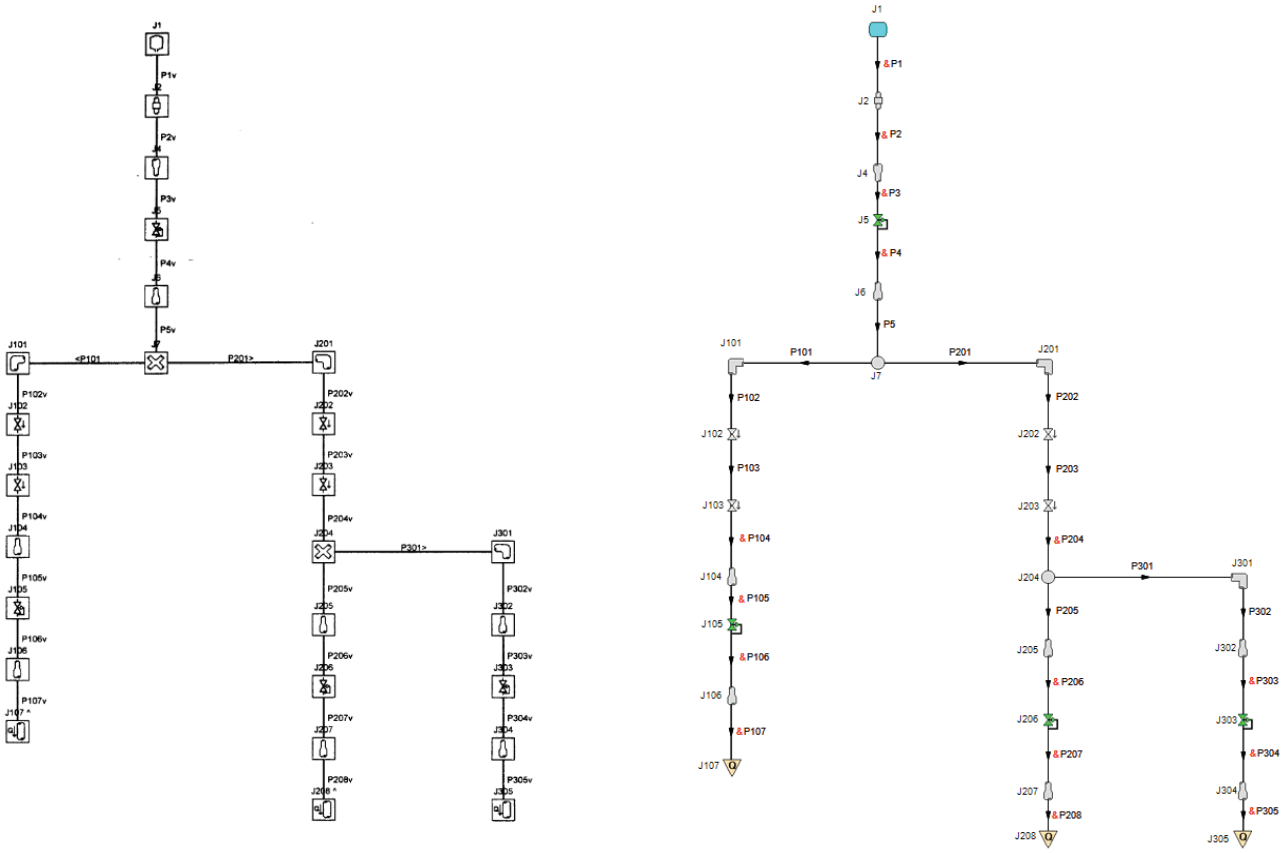
Applied Flow Technology celebrated its 25th anniversary in 2019. Over the course of its history, customer submitted case studies have affirmed the confidence and convenience AFT software enables. This case study was originally written in 1997 and was re-released as a retrospective in 2021.

KETEMA has used Fathom and Arrow on numerous systems including: Pressurization systems, nitrogen attitude control systems, and LO2, RP-1 and Ethanol propellant feed systems. The Arrow 1 model of the gaseous helium pressurant system for propellant tanks is shown in Figure 1, *mirrored with the modern Arrow 8 model. It is surprising the file still opens, let alone runs in a version 24 years later. Since 1997, AFT has also added isometric modeling options and other workspace improvements to make it easier to interpret your model.*

KETEMA had opportunity to check the AFT Fathom predictions against test data. AFT Fathom predictions of the rocket engine propellant feed system pressure drop agreed within 5% with data collected during firing tests on an engine test stand. *Even 24 years ago AFT software was tested and verified against field data. With the annual Platinum Pipe Award, even more case studies emphasizing result accuracy and data correlation are submitted each year.*

With the many aerospace fluid systems encountered at KETEMA, it appears that AFT Fathom and AFT Arrow will be put to good use in the future as well. With such unique piping systems, it is gratifying to see demonstrated AFT software's flexibility as general purpose pipe flow analyzers.

Senior Aerospace Ketema is a leading provider of components for aircraft and turbine engine builders, as well as precision products for space, marine and ground-based applications. Ketema specializes in producing complex fabrications and machined components from Titanium and Nickel Alloys.



AFT Arrow 1 (1997)

AFT Arrow 8 (2021)

Figure 1: A side-by-side comparison of the Helium pressurant system in Arrow 1 and Arrow 8. The resemblance is uncanny.

Top 10 AFT Features Released Since 1997

1. Organize your design variants into a single file with Scenario Manager
2. Visualize your data with enhanced graphing, including multi-scenario and stacked graphs
3. Export and import your data with Excel integration
4. Model heat transfer with built-in correlations both internal and external
5. Define mixtures with fluid property databases Chempak and NIST REFPROP
6. Calculate energy costs and capital costs from pipes and components
7. Import from CAESAR II® neutral files, Piping Component Files (.pcf) and GIS shape files
8. Customize model workspace with isometric drawing mode and background imagery
9. Find additional capabilities like goal-seeking and transient analysis with add-on modules
10. Add common components and pipe conditions to libraries for rapid, consistent modeling