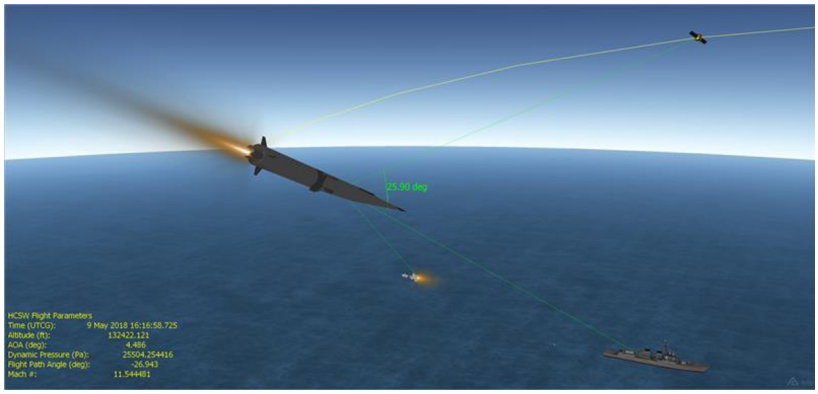
How STK Aviator Supports Hypersonic Systems Analysis

AGI's Systems Tool Kit (STK) includes nine core and 18 specialized modules and extensions. One of these, **STK Aviator**, is a critical module for the air warfare domain. STK Aviator adds advanced aircraft performance and propulsion models, maneuver profiles, and flight procedures to STK. Since 2018, one third of STK Aviator development has been driven by the hypersonics market.

STK's physics-based, multi-domain modeling environment enables you to create detailed scenarios of vehicles, their trajectories, and the threats around them. Since 1989, STK has helped the air and space communities tackle some of their hardest analytical modeling challenges in an easy to understand, 4D visual experience.

Continue reading to learn about the specific ways that STK Aviator can help engineers, operators, and analysts that work in this exacting domain.



STK Aviator can model a vehicle's full flight envelope in the hypersonic environment.

Vehicles traveling at typical hypersonic velocities and altitudes are significantly affected by variations in Earth's gravity and the curvature of its surface. By incorporating STK's highly accurate Earth gravity model with oblate rotating earth effects, including Coriolis effects, and then propagating using 6DOF dynamics, you can precisely model hypersonic and extra-atmospheric reentry trajectories. Using STK Aviator's flexible and modular UI, you can create high-representative trajectories in seconds.

STK Aviator provides representative hypersonic vehicle powerplant models and enables you to integrate your own.

In addition to traditional turbine models, STK Aviator includes ramjet and scramjet hypersonic engine models out of the box. The scramjet model includes both hydrocarbon and hydrogen models, and both ramjet and scramjet models support a rocket booster mode. STK Aviator also enables you to control the switchover from lower to higher speed engines in a single scenario, and uses independent fuel profiles for each. Finally, STK Aviator's API enables you to easily use your own powerplant models.

STK Aviator can model complex hypersonic flight path motion.

STK Aviator can compute a full force balance and can calculate lift-to-drag coefficients to accurately compute an aircraft's Angle of Attack (AOA). Using this capability, you can model a flight path that follows a constant AOA trajectory. For hypersonic vehicles, this results in an accurate model of the oscillating phugoid motion without having to prescribe this trajectory.

STK Aviator includes a hypersonic aerodynamic model.

STK Aviator's Advanced Fixed Wing performance system includes a hypersonic aerodynamic model. This "first principles" model can provide significant insights into vehicle performance in this regime. It uses the thin airfoil theory and enables you to independently control the frontal area ratio and transonic and wave drag factors for fine control over drag. The UI includes contours of AOA, the required thrust, leading edge and wing bottom temperatures, etc. as functions of altitude and Mach number. This makes it easy to evaluate and iterate on aircraft size and appropriate engine models.

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STK Aviator uses a Lambert midcourse guidance strategy to optimize trajectories.

STK Aviator includes a Lambert midcourse guidance strategy to generate and optimize the trajectory as the geometry and target and interceptor speeds evolve, so that the vehicle arrives at the terminal conditions with maximum energy. You can apply this to both offensive and defensive systems.

STK Aviator includes reporting tools and data specifically designed to support to hypersonic modeling.

The Advanced Fixed Wing performance model enables you to constrain the flight envelope by maximum total temperature. You can control climb, cruise, and descent performance model speeds by temperature, Mach number, or dynamic pressure limits. Finally, the Reports and Graphing tool includes static and total (stagnation) temperature data, as well as Reynolds number and associated viscosity values as standard outputs. Each of these tools helps you rapidly create and optimize hypersonic trajectories, accelerating concept and engineering design cycles.

STK Aviator can incorporate customer provided CFD data.

STK Aviator can ingest user-specified aerodynamic and propulsion lookup tables for lift and drag coefficients, fuel burn, and thermal model parameters. This enables you to plug computational fluid dynamics (CFD) data into STK Aviator to capture high-fidelity modeling within STK Aviator's flexible trajectory generation framework. For example, a surface temperature distribution exported from ANSYS Fluent fluid simulation software[1] can be ingested to ensure that STK's digital aircraft models represent the real-world CFD and wind-tunnel analysis being performed on many hypersonic programs.

1 For additional details on how to incorporate CFD into hypersonic vehicle analysis using Ansys and AGI software, see the webinar: Digital Mission Engineering Part 4, starting at 26:45 (youtu.be/62WKwel6uV0)

STK Aviator leverages the multi-domain capabilities of STK to model the full hypersonic mission environment, not just vehicle motion.

Because STK Aviator is directly integrated with the full multi-domain environment in STK, you can leverage other STK modules such as EOIR or Radar with Aviator to model the complete operational environment. This extends analysis beyond hypersonic vehicle performance, enabling you to analyze defensive systems' performance and potential operational impacts. For example, you could use Aviator and EOIR to assess the tracking capability of an EOIR spacecraft sensor and its ability to view a hypersonic vehicle throughout its trajectory. Also, by modeling a scenario with a segmented trajectory and different variables over time, Aviator and STK can be used for accurate kill chain analysis.

STK Aviator can integrate with other STK modules to seamlessly model from air to space.

STK Aviator can model a launch from a moving object, seamlessly transition from the air domain into suborbital spaceflight, and then back into the atmosphere. It can easily switch between the high-fidelity exo-atmospheric models provided by STK SatPro and the high-fidelity atmospheric models provided by STK Aviator.

STK Aviator supports test and evaluation through a tracking noise and estimation plugin.

STK Aviator includes a tracking noise and estimation plugin system that enables guidance strategies to fly with noise and tracking errors. It can also interface directly with MATLAB to evaluate hypersonic noise.

Learn more: call 1 610-981-8000 or visit agi.com

Additional AGI resources

Web pages and articles

- **Hypersonic Missions**. Describes the nature of hypersonic missions and how they inherently pair with STK's strengths. agi.com/missions/hypersonics-missions
- **STK Aviator**. Describes the STK Aviator module's capabilities and provides links to additional information, including the product spec sheet. agi.com/products/stk-specialized-modules/stk-aviator
- **Modeling the Coriolis Effect is a Breeze with STK**. Describes the updates to STK 12.0 that enable you to account for Coriolis effects on aircraft trajectories. agi.com/articles/modeling-the-coriolis-effect-is-a-breeze-with-stk

Videos

- **Modeling Hypersonic Missions.** Provides a quick look at STK Aviator in action, modeling a hypersonic mission. Approximately 6 minutes. youtu.be/ocdec2GLcTY
- **Aviator High and Fast**. Tom Neely, principal developer of STK Aviator, walks through the new features in STK 12.0 that support hypersonic vehicle flight path modeling. Approximately 17 minutes. https://youtu.be/9RNDH0H5S70
- **DME: Mission Performance for Hypersonic Systems webinar**. AGI Systems Engineer Mo Syed uses analysis of a NASA B52/Pegasus/X-43 hypersonic vehicle system as an example of digital mission engineering (DME). Approximately 47 minutes.
  - Video: youtu.be/mMRoff-S0-I[2]
  - FAQs about this webinar: agi.com/missions/air-systems-missions/frequently-asked-questions-mission-performance-for
  - Detailed instructions on how to recreate the scenario: help.agi.com/stk/index.htm#training/DME_Hypersonics.htm?Highlight=hypersonic

2 NOTE: 15:01-27:07 focuses on Aviator's hypersonic capabilities; 27:07-37:35 provides a great discussion on hypersonic vehicle tracking using thermal modeling and STK EOIR; 37:35- 44:54 covers communications modeling, including plasma effects.

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