Status of the AIAA Modeling and Simulation Format Standard

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Overview

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  - Motivation for standard format
  - Goal of effort
- Proposed solution
  - AIAA/ANSI/ISO standard
  - Applications for standard
- Examples
- Tools
- Status
- Summary

Background

Because…

- Independent development of R&D sim labs
- Incomplete standards - just a few, locally applied
- Different architectures (data table formats, variable names, measurement axes, moment transfer method)

And with…

- Increased reliance on flight simulation for research & development and procurement
- Increased need for collaboration and teaming

We should explore…

- Possibilities for increasing productivity
- More *portable* simulation models is the goal

Motivation

- *Amazing fact:* Flight dynamic models from different organizations are usually **incompatible** with each other
  - Delivering or updating a flight dynamics model between contractor, government, or training simulation facilities can take **months**
  - There are valid, historical reasons for this
  - Still, this is a major hindrance to cooperative research & updating training fidelity
- Think PC vs. Mac, only less compatible!
- Simulation rehosting is similar to swapping out train trucks (wheel assemblies) when changing rail gauge…

Changing rail gauge in Manzhouli, China

Example for single aircraft type

- A 2002 NASA/SAIC estimate for one fighter type*:*

Pilot Training Devices	**Research Simulations**
31 simulators	28 simulators
6+ model types	16 locations

- 59 mostly incompatible simulations (built by different vendors/software architecture)
- Potential savings: $ 6 M ***per year*** for ***single*** type

Solution: standard exchange format

Simulator Site A
(for example-
a RDT&E simulator)

Standard Import/
Export Tools

Simulator Site B
(for example-
An analysis simulation)

Standard Import/
Export Tools

Standard
Exchange
Format

Standard Import/
Export Tools

Simulator Site C
(for example-
a training simulator site)

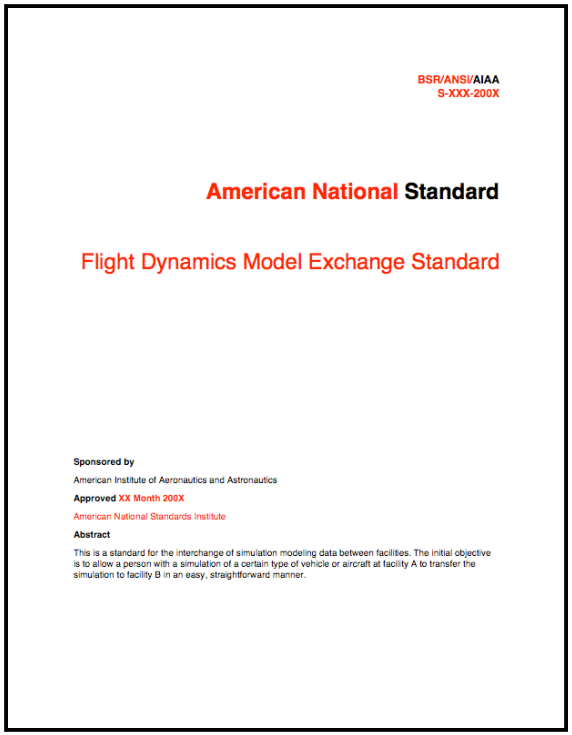
Only need to build one set of import/export tools

http://daveml.nasa.gov

Project background

- Hildreth (1998) proposed dev of AIAA standard
- Hildreth and Jackson (2002) showed $ 6 M savings for one aircraft type
- Dynamic Aerospace Vehicle Exchange Markup Language (DAVE-ML) proposed in 2002
- Successful model exchange between NASA Ames and NAVAIR Patuxent River held in 2004
- Initial DAVE-ML grammar in use for aero models (DSTO, NASA Langley, NAVAIR)

Proposed solution


BSR/ANSI/AIAA
S-XXX-200X

American National Standard

Flight Dynamics Model Exchange Standard

Sponsored by

American Institute of Aeronautics and Astronautics

Approved XX Month 200X

American National Standards Institute

Abstract

This is a standard for the interchange of simulation modeling data between facilities. The initial objective is to allow a person with a simulation of a certain type of vehicle or aircraft at facility A to transfer the simulation to facility B in an easy, straightforward manner.

- AIAA/ANSI draft model exchange standard
  - Standard variable names; axis systems per AIAA/ANSI R-004-1994
  - Model implemented in XML extension: DAVE-ML
- Applications
  - Static subsystem models (the major components of a flight model)
    - Aerodynamic models
    - Mass/inertia models
    - Performance models
  - Dynamic models
    - Integration of states are not explicitly included in this standard
    - External integration of states is possible, however
    - Will be a backwards-compatible XML implementation
    - Will not include standard equations of motion (F=ma)

http://daveml.nasa.gov

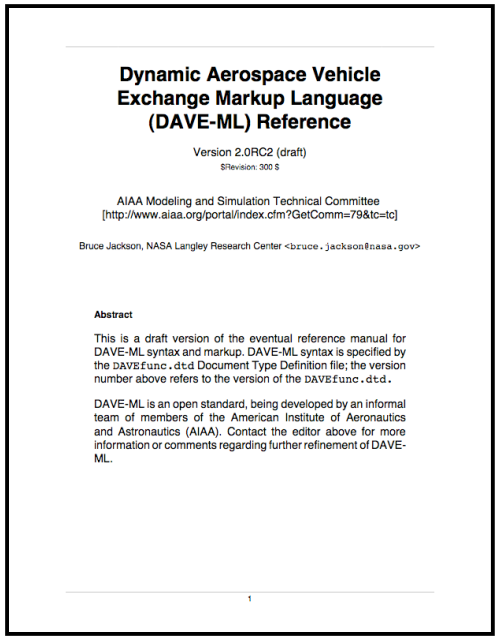
The proposed standard includes:

- An ***exchange*** standard for flight dynamic models
  - Does not require internal adoption of format
  - Does not require replacement of legacy code & tools
- Standard variable names for common parameters
  - Includes units of measurement for most parameters
  - Describes how to construct & interpret new names
  - Does not require internal adoption of new names
- Incorporates existing standard for axis systems
- Initial application: encoding of aero & mass models
  - These represent sizeable portions of flight simulation data

DAVE-ML introduction

Dynamic Aerospace Vehicle Markup Language

- Based on Extensible Markup Language (XML)
- Currently includes
  - Function data tables (N-dimensional)
  - Non-linear build-up equations
  - Units, sign convention
  - Provenance of model
  - Uncertainty/statistical bounds
  - Static check case data
- Self-documenting text file



Dynamic Aerospace Vehicle Exchange Markup Language (DAVE-ML) Reference

Version 2.0RC2 (draft)

$Revision: 300 $

AIAA Modeling and Simulation Technical Committee
[http://www.aiaa.org/portal/index.cfm?GetComm=79&tc=tc]

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Abstract

This is a draft version of the eventual reference manual for DAVE-ML syntax and markup. DAVE-ML syntax is specified by the `DAVEfunc.dtd` Document Type Definition file; the version number above refers to the version of the `DAVEfunc.dtd`.

DAVE-ML is an open standard, being developed by an informal team of members of the American Institute of Aeronautics and Astronautics (AIAA). Contact the editor above for more information or comments regarding further refinement of DAVE-ML.

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http://daveml.nasa.gov

DAVE-ML examples/test cases

F-16 subsonic aero model (from NASA TM)

- 51 variables, 18 tables, 744 points
- Switches & absolute value nonlinear elements
- 17 verification checkcases included
- 154 KB file with 2,712 lines

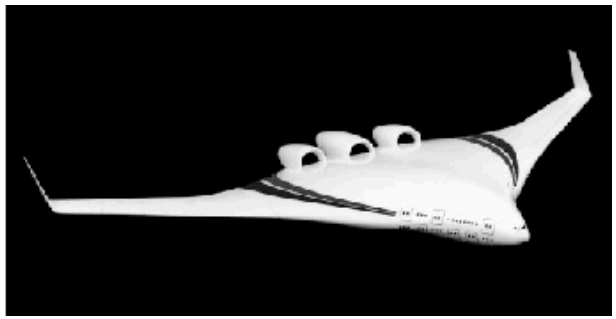
Concept development lifting body aero model

- Supersonic and subsonic regimes
- Polynomial equations; tables of coefficients
- 361 variables, 168 tables, 6,240 values
- 24 verification checkcases included
- 1.2 MB file with 22,299 lines

These examples are available on project website

http://daveml.nasa.gov

Other DAVE-ML uses



NASA/Boeing Blended-wing-body (X-48A)

- Complete aero model in 12.5 MB text file
- 22 breakpoint sets, 97 tables (up to 5-D)
- 256 functions using 716,826 data points
- Compresses to 2.6 MB
- Parsed in 5 seconds on average PC

Boeing X-37 air-launched test vehicle

- Boeing data in Excel tables
- Langley simulation in Simulink
- DAVE-ML used as intermediate format
- Generated multiple Simulink models, one per Excel file

Other DAVE-ML uses

Orion launch abort vehicle
(CEV with the escape tower)

- 46,332 data points, 3 inputs, 8 outputs
- 385 KB text file
- Includes uncertainty & checkcases

Available DAVE-ML tools

- DAVE-ML 2.0 format specification DTD
- DAVE-ML 2.0 reference manual
- JANUS (C++ library) - Australian DSTO
- LaSRS++ (C++ library) - NASA Langley
- NASA Ames FTP tool (import/export Perl scripts)
- NASA Langley XSLT conversion script
  DAVE-ML => HTML (self-documenting!)
- DAVEtools (Java) - NASA Langley:
  DAVE-ML => Simulink (popular analysis engine)
- SAIC developing Python-based DAVE-ML editor
  (supports Joint Next-Gen Threat System, NGTS)

Status

- Standard format is in use within parts of NASA and Australian DSTO; being applied to Joint Next-Gen Threat System (NGTS) by NAVAIR
- Draft standard submitted to main AIAA Standards organization by AIAA Modeling and Simulation Technical Committee October 2007; currently in editing
- Main application is exchange of aero models, but can be used to specify entire flight dynamics package.
- Wider review (public comment period) after AIAA publishes draft standard

Follow-on opportunities

- Add time history check data format (possibly HDF-5?)
  - Needed for dynamics verification
  - Would like to reuse JSF time-history HDF-5 tools
- Add support for vectors & matrices
  - Current request from DSTO
- Add specification for integration methods
  - Initial condition logic, numerical method selection
  - Add past value / zero-order-holds
- Add support for subsystems/libraries
  - Currently one monolithic model

Summary

- Draft standard for static (aero) models developed; in review by AIAA/ANSI
- Initial set of tools are appearing
- In use by Australian DSTO for threat models
- US Navy building first set of threat models
- Further development for full dynamic models
- Seeking wider (voluntary) participation

http://daveml.nasa.gov

Backup slides

Previous model standards efforts

- MODSIM

  Air Force initiative, mid-80s, standard CPUs/SW

- SIMNET/WARNET - DIS - HLA

  1980s DARPA project to network/fight existing sims

- Project 2851 - SEDRIS

  Standard visual/terrain model database formats

- Internal NASA: NASP project

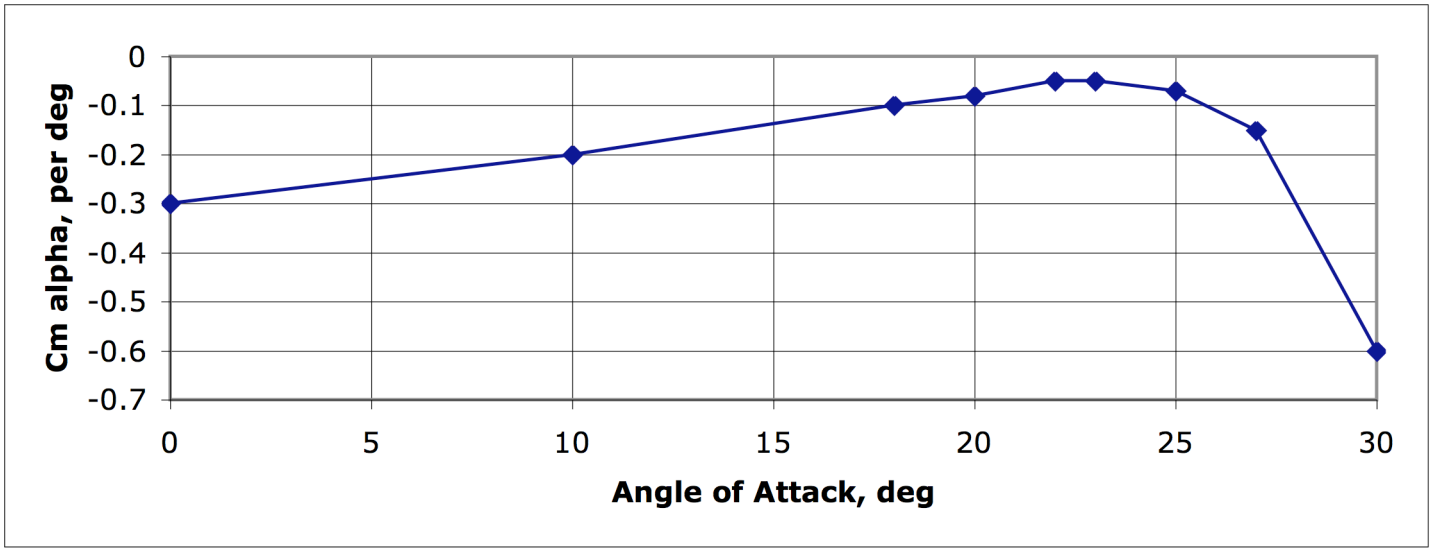
  Late 80s internal NASA: Fortran-only, but standard table format, axes, variable names (8 characters)

DAVE-ML simple example


```
<?xml version="1.0" standalone="no"?>
<!DOCTYPE DAVEfunc SYSTEM "DAVEfunc.dtd">
<DAVEfunc>
  <variableDef
    varID="angleOfAttack_d"
    name="Alpha" units="deg"
  />

  <variableDef
    varID="CmAlfa" name="Cma" units=""
  />

  <breakpointDef
   bpID="angleOfAttack_d_bp1">
    <bpVals>
    0, 10, 18, 20, 22, 23, 25, 27, 30
    </bpVals>
  </breakpointDef>
```

```
  <griddedTableDef gtID="CmAlfa_Table1">
    <breakpointRefs>
      <bpRef bpID="angleOfAttack_d_bp1"/>
    </breakpointRefs>
    <dataTable>
    -0.3, -0.2, -0.1, -.08, -0.05, -0.05,
    -0.07, -0.15, -0.6
    </dataTable>
    </griddedTableDef>

  <function name="Cm_alpha_func">
    <independentVarRef varID="angleOfAttack_d"/>
    <dependentVarRef varID="CmAlfa"/>
    <functionDefn>
      <griddedTableRef gtID="CmAlfa_Table1"/>
    </functionDefn>
  </function>

</DAVEfunc>
```

AeroML simple example (cont'd)



Previous XML syntax encodes this function:

Possible to encode, but not shown, are

- buildup equations (combinations of functions)
- confidence bounds associated with this function

Janus API library

- Developed by Australia's Defence Science & Technology Organization (DSTO)
- Janus is a C++ library to read/write and manipulate DAVE-ML files
- Reads DAVE-ML directly at run-time
- AES-256 encryption for classified models
- Associated Matlab code to read/write DAVE-ML
- Available under Open Source license from DSTO