Progress Toward a Format Standard for Flight Dynamic Models

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Overview

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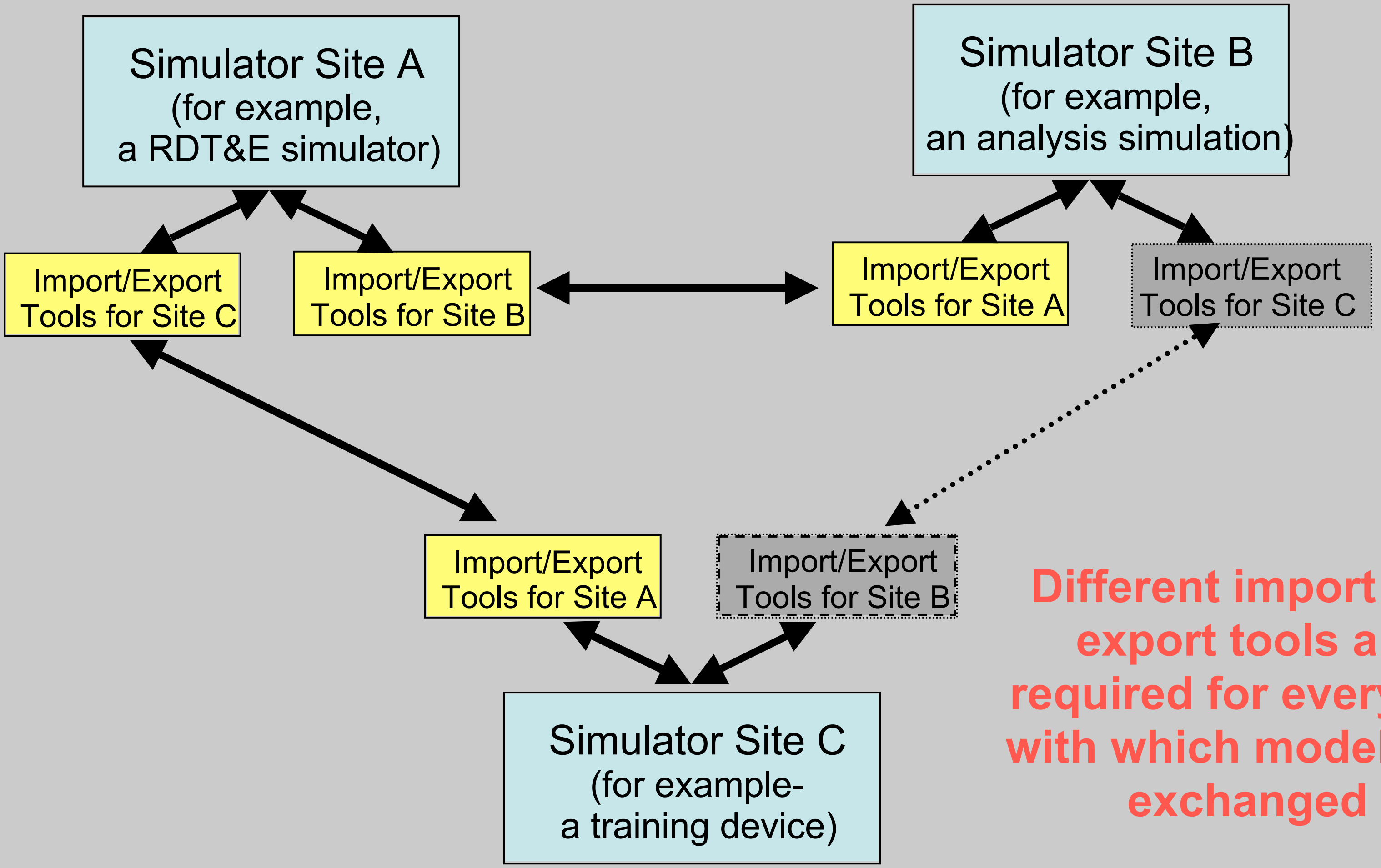
Motivation, Background, Goal

- Independent development of gov't/industry flight sims
- Incomplete standards - a few locally applied
- Incompatible math models (esp. data formats & variable names) are a significant hindrance to rapid sharing
- Increased reliance on flight simulation
  for research & development and procurement
- Increased need for collaboration and teaming
- Possibilities for increased productivity
- *Portable* simulation models is the goal

Why are we (two AIAA yokels) here?

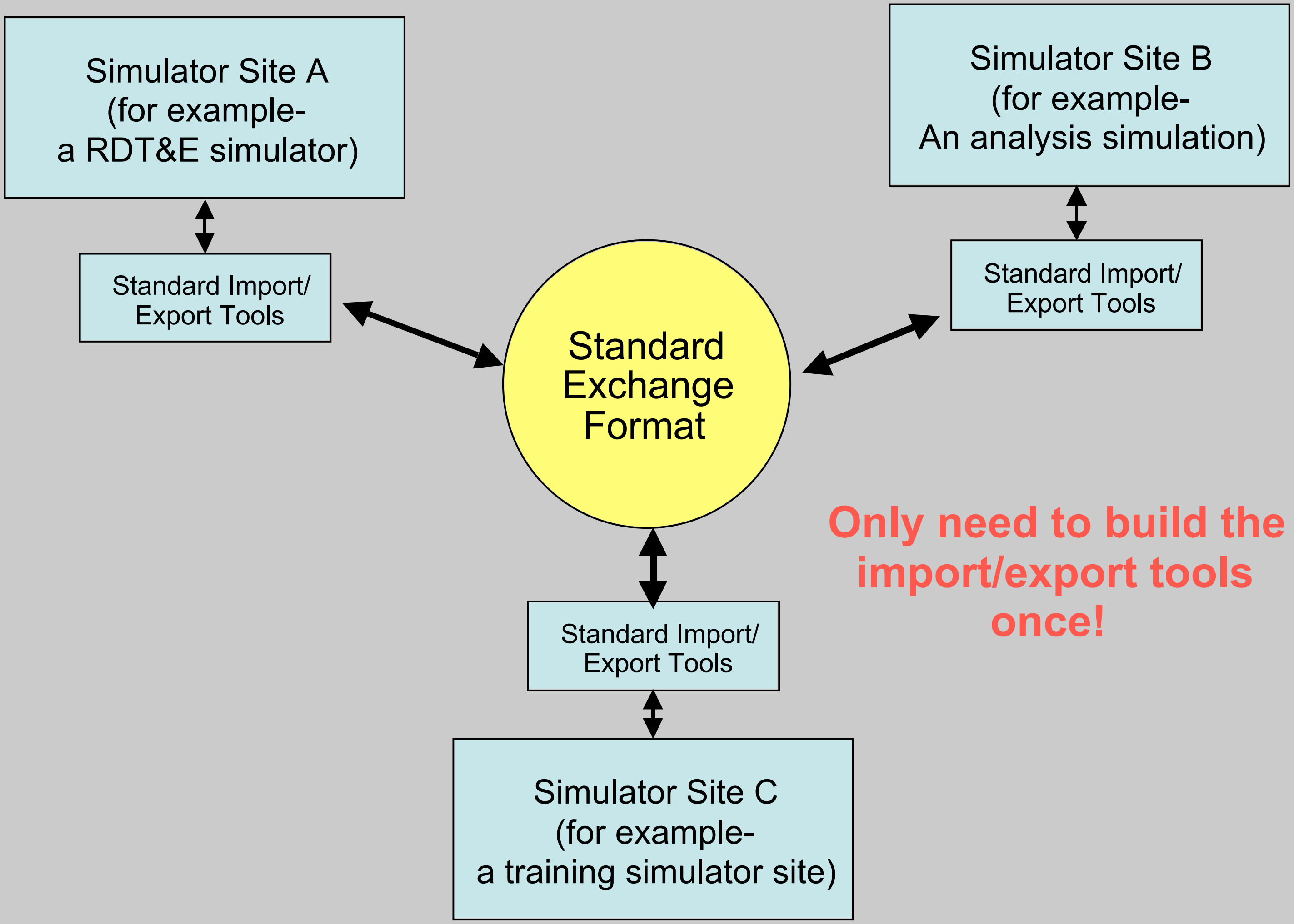
- Here to avoid duplication of effort
- Would like to coordinate our AIAA/ANSI standard with SISO/IEEE organizations
- Would like feedback from SISO
- Would like to share standards-lessons-learned

Present situation: sim exchange



Different import and export tools are required for every site with which models are exchanged

Solution: standard exchange format



Only need to build the import/export tools once!

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 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 demo between NASA Ames and NAVAIR Patuxent River reported in 2004
- DAVE-ML subset, AeroML, in use for aero models (DSTO, NASA Langley)

Proposed solution

- AIAA/ANSI draft standard
  - Standard variable names
  - Model implemented in XML: DAVE-ML
- Applications
  - Static subsystem models
    - Aerodynamic models
    - Mass/inertia models
    - Performance models
  - Dynamic models
    - Models with states are not yet supported by standard
    - Will be a backwards-compatible XML implementation

The proposed standard includes:

- An ***exchange*** standard for static flight models
  - Does not require internal adoption of format
  - Does not require replacement of legacy code & tools
- Includes standard variable names for common signals & measures
  - Describes how to construct new names
  - Incorporates existing standard for axis systems
- Encoding of static systems: aero & mass models
  - These represent sizeable data within flight simulations

DAVE-ML introduction

Dynamic Aerospace Vehicle Markup Language

- Based on Extensible Markup Language (XML)
- Currently includes
  - Function data tables or polynomial expressions
  - Build-up equations
  - Units, sign convention
  - Background (provenance) of model
  - Uncertainty descriptions
  - Static check case data
- Self-documenting text file

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>
```

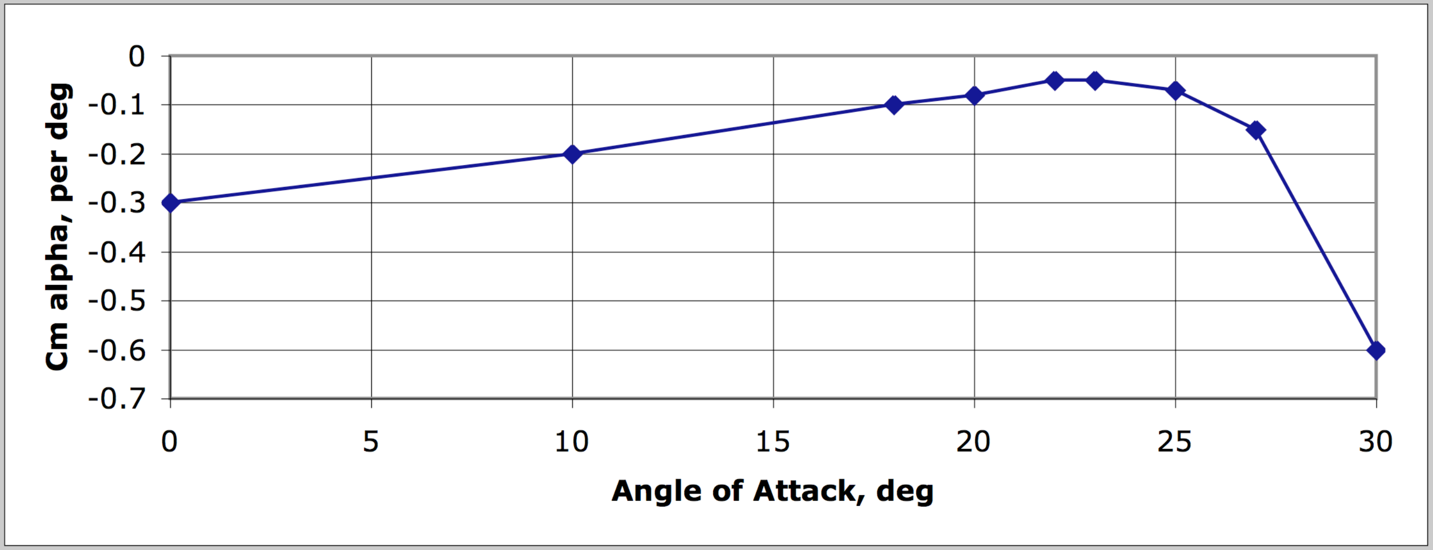
```
<griddedTableDef gtID="CmAlfa_Table1">
  <breakpointRefs>
    <bpRef bpID="angleOfAttack_d_bp1"/>
  </breakpointRefs>
  <dataTable>
 -0.3, -0.2, -0.1, -.08, -0.05, -0.05,
 -0.07, -0.15, -0.6
  </dataTable>
 </griddedTableDef>

<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

DAVE-ML examples/test cases

F-16 subsonic aero model

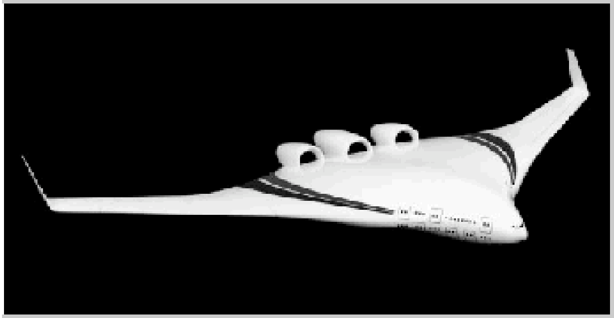
- 51 variables, 18 tables, 744 points
- Switches & absolute value nonlinear elements
- 17 verification checkcases included
- 154 KB file with 2,712 lines

Concept development lifting body aero model

- Supersonic and subsonic regimes
- 361 variables, 168 tables, 6,240 points
- 24 verification checkcases included
- 1.2 MB file with 22,299 lines

These examples are available on project website

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

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

Current DAVE-ML uses

Orion launch abort vehicle
(CEV with and w/o escape tower)

- 46,332 data points, 3 inputs, 8 outputs
- 385KB text file
- AeroML is used as an intermediate format between Johnson Space Center and Langley Research Center analysis tools

Available DAVE-ML tools

- DAVE-ML DTD (see website)
- DAVE-ML reference manual (see website)
- JANUS (C++ library)
  - Australian DSTO/Ball Aerospace
- NASA Ames FTP tool (import/export Perl scripts)
- XSLT conversion script
  DAVE-ML => XHTML
- DAVEtools (Java packages):
  DAVE-ML => Simulink

Janus API library

- Developed by Australia’s Defence Science & Technology Org (DSTO) (G. Brian)
- 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

Status

- Standard format is in use within parts of NASA and Australian DSTO
- Draft standard being reviewed as ANSI standard by AIAA Modeling and Simulation Technical Committee
- Comments due back at the end of October
- Wider review (public comment period) after AIAA approves draft standard

Summary

- Draft standard for static models developed
- Initial set of tools are appearing
- Adopted by Australian DSTO for internal flight model library
- Draft is presently under review by
  AIAA technical committee as ANSI standard

http://daveml.nasa.gov