

Experiments with DAVE-ML

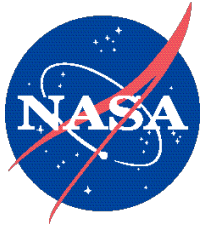
Flight Dynamic Model Exchange using XML

A briefing to the AIAA Simulation Facilities Working Group
and Modeling & Simulation Technical Committee

SUNY/Binghamton - May 19, 2003

Bruce Jackson

<e.b.jackson@nasa.gov>



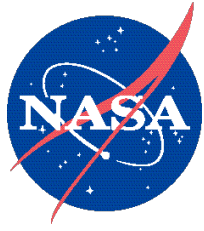
Motivation

- 100 years of flight - 1 / 2 with simulators
- My own career - 1 / 5 of "flight century"
 - Still doing simulations same way
 - Semi-automatic rehosting of models takes months
- Teaming across gov't / industry common
- Over half of HSCT research period spent rehosting models (four facilities involved)
- Over \$ 6 M lost each year in *one* aircraft type due to lost productivity in flight dynamic model maintenance, negative training



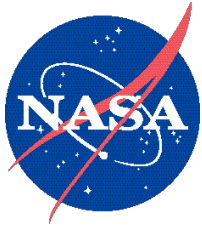
What is DAVE-ML?

- **Dynamic Aerospace Vehicle Exchange Markup Language** is an attempt to develop a way to encode a flight vehicle's dynamic model in a vendor-neutral, programming-language-independent way.
- DAVE-ML supports and depends on proposed AIAA MSTC simulation standards for function tables and signal names
- DAVE-ML is based on XML, an open Web standard



What is XML?

- XML (like HTML) is based on SGML, an early ISO standard for electronic information storage & exchange
- XML is a flexible, extensible meta-markup language where information is delineated by contextual tags
- XML is not a programming language



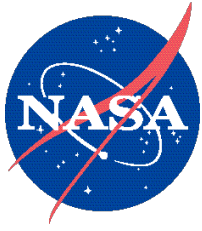
XML syntax (human readable)

- Elements (info surrounded by tag pair)
`<mytag>information</mytag>`
- Attributes (info embedded in tag)
`<mytag important="yes">information</mytag>`
- Empty elements (single tag as flag)
`<useEnglishUnits/>`
- Comments
`<!-- a comment goes here -->`



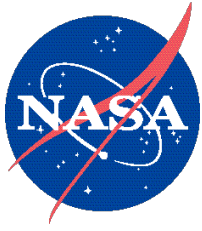
Relationship to AIAA MSTC efforts

- DAVE-ML proposed to implement draft AIAA standard practice regarding
 - Variable names
 - Function table information
- Additional standards may be rolled in
- DAVE-ML may be offered to AIAA as standard



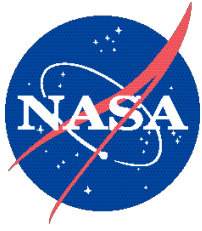
DAVE-ML purpose

- Intended to encode complete high-fidelity flight model in a non-proprietary, facility-independent way
- First step: static models (tables & equations)
 - Aerodynamic model
 - Inertial subsystem models
- Next step:
 - Checkcase data (static & dynamic)
 - Time-history data
- Eventually include dynamic elements



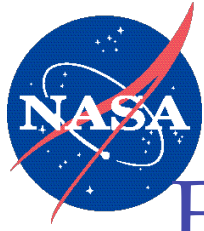
DAVE-ML benefits

- Combines all data, algorithms in one place
- Includes confidence bound / statistics (for Monte Carlo studies in R&D)
- Programming-language-independent
- Facility-neutral
- Open standard – non-proprietary
- Includes data provenance, references, hyperlinks to documents



XML benefits

- Universally transportable, human-readable format
- Self-documenting
- Single XML source file can directly generate
 - Real-time simulation modules
 - CAD analysis models (Simulink)
 - Documentation (Web & PDF)
 - Unlimited other formats... using XSLT



Example: F-16 subsonic aero model

```
<?xml version="1.0" standalone="no"?>
<!DOCTYPE DAVEfunc SYSTEM "DAVEfunc.dtd">
<DAVEfunc>
  <fileHeader>

    <author name="Bruce Jackson" org="NASA Langley Research Center" xns="@bjax"/>
    <fileCreationDate date="28-MAR-2002"/>
    <description>
      F-16 Aero Data file. Based on Morelli's adaptation of
        Stevens and Lewis' F-16 example [1] described in Garza &
        Morelli's TM [2]. Obtained from E. A. Morelli in the form of
        Matlab scripts [3] & [4]
    </description>

    <!-- ===== -->
    <!--   References   -->
    <!-- ===== -->

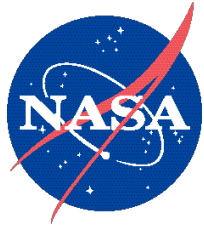
    <reference refID="REF01" author="Stevens, Brian L. and Lewis, Frank L."
      title="Aircraft Control and Simulation"
      accession="ISBN 0-471-61397-5" date="1992"/>

    <reference refID="REF02" author="Garza, F. R.; and Morelli, E. A."
      title="A Collection of Nonlinear Aircraft Simulations
      in MATLAB" accession="NASA TM-2002-xxxxxx" date="JUN-2002"/>

    <reference refID="REF03" author="Morelli, Eugene A."
      title="f16_aero.m" date="17-JUN-1995"/>

    <reference refID="REF04" author="Morelli, Eugene A."
      title="f16_aero_setup.m" date="17-JUN-1995"/>

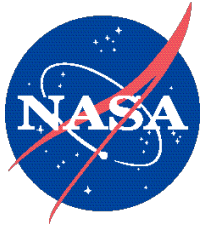
  </fileHeader>
```



Example aero model (constants)

```
<variableDef name="rtd" varID="rtd" units="deg/rad">
  <description>
    Conversion constant from radians to degrees
  </description>
  <calculation>
    <math>
      <apply>
        <divide/>
        <cn>180.</cn>
        <cn>3.14159265</cn>
      </apply>
    </math>
  </calculation>
</variableDef>

<variableDef name="xcgr" varID="xcgr" units="fract" initialValue="0.35">
  <description>
    Default location of center of gravity relative to wing leading
    edge, expressed as a fraction of aerodynamic chord length.
  </description>
</variableDef>
```

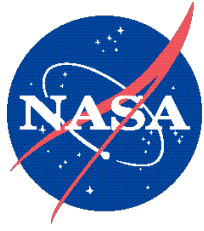


Example aero model (inputs)

```
<variableDef name="True_Airspeed_f_p_s" varID="vt" units="ft/sec">
  <description>
    True airspeed, ft/sec
  </description>
</variableDef>

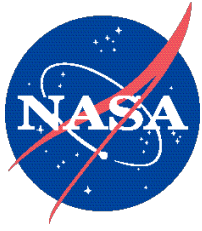
<variableDef name="Angle_of_Attack_deg" varID="alpha" units="deg" symbol="&#x3B1;">
  <description>
    Instantaneous true angle-of-attack, in degrees
  </description>
</variableDef>

<variableDef name=" Angle_of_Sideslip_deg " varID="beta" units="deg" symbol="&#x3B2;"
  sign="+wind in right ear">
  <description>
    Instantaneous true angle-of-sideslip, in degrees
  </description>
</variableDef>
```



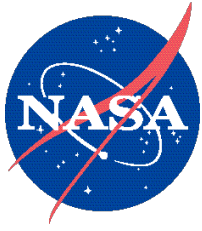
Example aero model (intermediate calculations)

```
<variableDef name="drdr" varID="drdr" units="">
  <description>
    Normalized rudder deflection.
  </description>
  <calculation>
    <math>
      <apply>
        <divide/>
        <ci>rdr</ci>
        <cn>30.0</cn>
      </apply>
    </math>
  </calculation>
</variableDef>
```



Example aero model (output calculation)

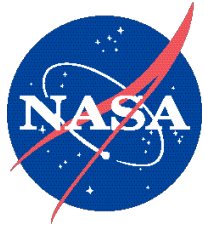
```
<variableDef name="Cl0" varID="clt" units="" sign="+right wing down">
  <description>
    Basic coefficient of moment around the X-body direction (roll) (+RWD)
  </description>
  <calculation>
    <math>
      <apply>
        <piecewise>
          <piece>
            <apply><minus/><ci>absCl0</ci></apply>
            <apply><lt/><ci>beta</ci><cn>0</cn></apply>
          </piece>
          <otherwise>
            <ci>absCl0</ci>
          </otherwise>
        </piecewise>
      </apply>
    </math>
  </calculation>
</variableDef>
```



Example aero model (function)

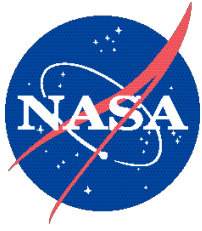
```
<function name="Basic Cl">
  <description>
    Basic coefficient of rolling moment as a function of angle of attack and sideslip angle
  </description>
  <provenance>
    <author name="Bruce Jackson" org="NASA Langley Research Center" xns="@bjax"/>
    <functionCreationDate date="28-MAR-2002"/>
    <documentRef docID="REF01"/>
    <documentRef docID="REF02"/>
    <documentRef docID="REF03"/>
  </provenance>
  <independentVarRef varID="absbeta" min="0.0" max="30.0" extrapolate="neither"/> <!-- Beta breakpoints -->
  <independentVarRef varID="alpha" min="-10.0" max="45.0" extrapolate="neither"/> <!-- Alpha breakpoints -->
  <dependentVarRef varID="absCl0"/>

  <functionDefn name="Cl0_fn">
    <griddedTable name="Cl0_table">
      <breakpointRefs>
        <bpRef bpID="BETA1"/>
        <bpRef bpID="ALPHA1"/>
      </breakpointRefs>
      <dataTable> <!-- Note: last breakpoint changes most rapidly -->
        0., 0., 0., 0., 0., 0., 0., 0., 0., 0., 0.,
        -.001,-.004,-.008,-.012,-.016,-.022, -.022,-.021,-.015,-.008,-.013,-.015,
        -.003,-.009,-.017,-.024,-.030,-.041, -.045,-.040,-.016,-.002,-.010,-.019,
        -.001,-.010,-.020,-.030,-.039,-.054, -.057,-.054,-.023,-.006,-.014,-.027,
        .000,-.010,-.022,-.034,-.047,-.060, -.069,-.067,-.033,-.036,-.035,-.035,
        .007,-.010,-.023,-.034,-.049,-.063, -.081,-.079,-.060,-.058,-.062,-.059,
        .009,-.011,-.023,-.037,-.050,-.068, -.089,-.088,-.091,-.076,-.077,-.076
      </dataTable>
    </griddedTable>
  </functionDefn>
</function>
```



DAVE-ML challenges

- Need graphical editor tool
- Need to define dynamic elements
- Need convention for modularity (e.g. top-level inputs / outputs for aero)
- No code generator example yet
- Need to tackle checkcase information
 - Checkcase descriptions & testing steps
 - Time history data encoding method



DAVE-ML status

- Static models with gridded tables supported
 - DTD (DAVEfunc) version 1.4 available for testing
 - Version 1.5 out shortly (reusable tables)
- Initial demo of DAVE-ML:
 - Exchange of aero models between Pax MFS & Ames SIMLAB in work!
- Web site established:
<http://dcb.larc.nasa.gov/utils/fltsim/DAVE>
- Preliminary tools include
 - Simulink model generator (Java)
 - HTML file description generator (XSLT)
- Mailing list server established:
simstds@larc.nasa.gov