Flight Dynamic Model Exchange using XML

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Outline

- Background
  - History of AIAA flight simulation standards
  - Concept - what the standard is meant to be
- Business case - potential savings
- Requirements review
- Introduction to XML
- F-16 model example
- Future steps
- Conclusions

History of Vehicle Dynamic Standards

- M&S T.C. started standards effort in early 1990's
- Efforts focused on vehicle dynamics
- Objective: to facilitate the exchange of a math model from one site to another
- Current status: Standard developed, including
  - Definitions- axis systems and variable names
  - Function table data
  - Time history data

Concept

- Need for standard representation of vehicle dynamics/aerodynamics
- Get away from ad-hoc, site-specific “standards”
- Many are possible; we’re proposing one
- Standard is superset of typical site-specific standards
- “SEDRIS-like” import/export from/to standard
- No requirement for internal use in your simulator!

Simple Cost Model to Estimate Savings Due to a Standard

- Considered one aircraft type: a manned military combat aircraft (actual data)
  - Pilot training devices
    - 31 simulators
    - 6+ models
  - Research simulators
    - 28 simulators
    - 16 locations

Simple Cost Model to Estimate Savings Due to a Standard

- Savings in maintaining the simulation models
  - The standard makes it easier to import and export model changes
- Savings due to less bad training or research time
  - Better maintenance results in less lost time
- Savings from improved productivity throughout the community of simulators
  - Easier exchange of information results in more model improvements exchanged throughout the community and consequent better quality of training and better research results.

Business case (3/5)

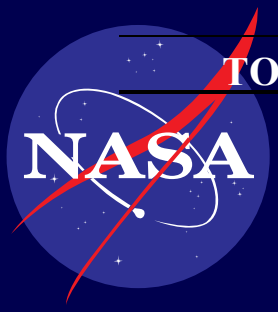
Cost Model Assumptions

	Pilot Training Simulator		Research Simulator (Desktop s/w)	
Years Use	10		10	
Hrs/yr Utilization	4,160	52 weeks x 2 shifts x 8hrs/shift	500	
Acquisition Cost	$25M		$300K	2 MY to install
Operational Cost (H/W parts)	$300/hr	5% of acquisition cost	$0/hr	N/A
Operational Cost (Manpower)	$145/hr	2 maintenance and 2 operator FTEs	$300/hr	1 FTE to maintain and operate the sim.
Amort. Of device	$601/hr		$60/hr	
Total Cost/hr	$1,046/hr		$360/hr	
# Changes /yr	0.25	Every fourth yr.	1	One change per yr
Cost for 1 Change	$240K	16 MM effort	$30K	2 MM effort

Business case (4/5)

Savings

	Pilot Training	Research		Savings Factor	
1) Total Cost to Implement Model Changes Without a Simulation Standard					
Total Cost of Changes Per Year	$360,000	$480,000	**$840,000**	**0.5**	**$420,000**
2) Cost of Lost Trainer or Research Time					
Lost hrs per trainer due to model errors and the time to fix them	100	50			
Total Cost of Lost Time per Year	$3,241,587	$504,000	**$3,745,587**	**0.5**	**$1,872,793**
			Sub Total		**$2,292,793**
3) Improved Trainer Community Productivity				**2.0**	**$4,585,587**
TOTAL ANNUAL POTENTIAL SAVINGS FOR ONE A/C TYPE					**$6,878,380**



Business Case Summary

- Conservative analysis: $6.8M+ savings/yr.
- Typical case for a military aircraft
- Results in an average savings of $117K per year per simulator
- Savings only makes sense when applied to the whole community
- Savings to the entire simulator industry is many times this amount

Key Requirements for a Standard

- Function table data- required to transfer non-linear model components-standard adds:
  - Provenance
  - Statistics
- Time history data- required to verify proper model transfer
- Definitions (variable names)- required to clearly state what the transferred information is (units, axis system, sign convention, etc)

Requirements review (2/2)

Function table with statistics and provenance

Four elements per data point

Independent variables

Reference

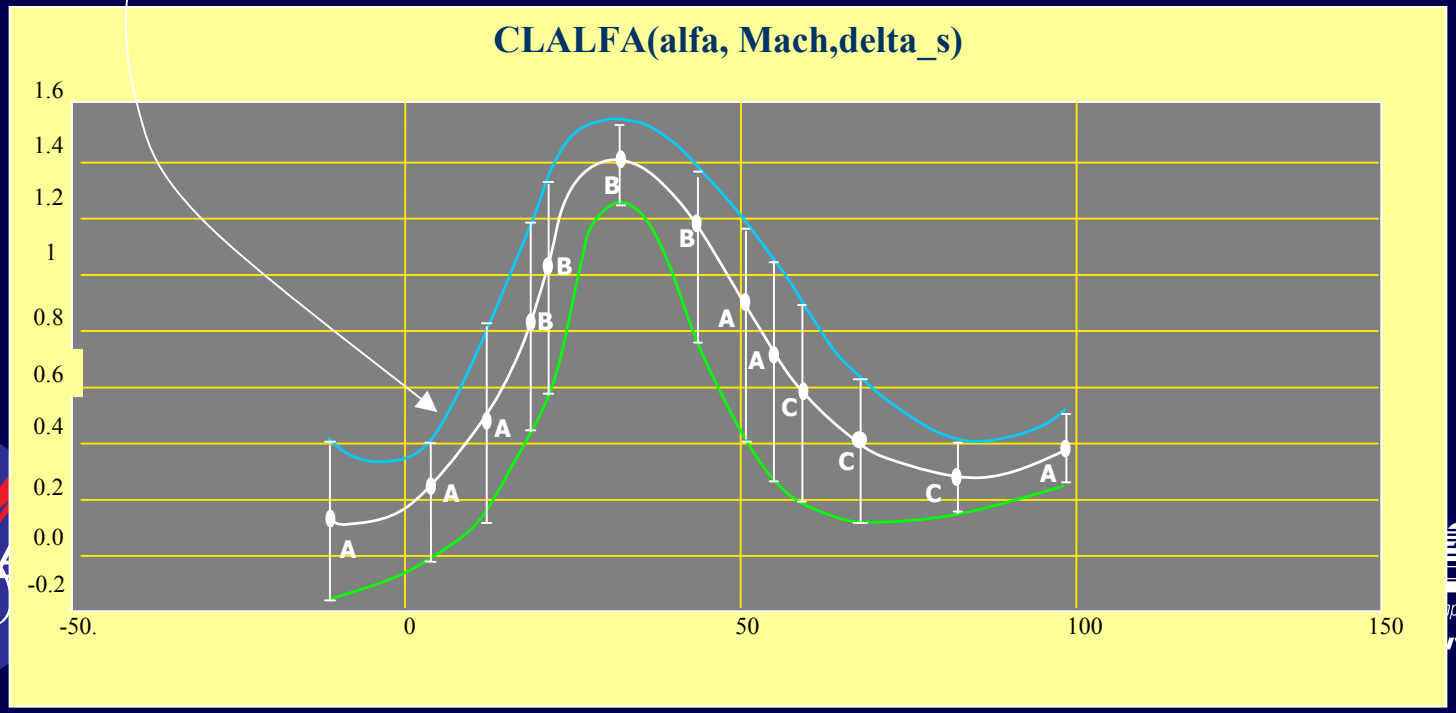
δ_s, Mach, α, C_L, ref, $-\sigma$, σ

0.0, 0.8, 90, 0.60, C, -.0032, 0068

Dependent variable

Statistics

The statistics data (the confidence intervals) are optional



XML: eXtensible Markup Language

- Emerging as new standard for storing data
- Text-based, human-readable, UNICODE
- Tags are used (a la HTML) to identify content
- Specialized tag sets are developed for a specific application; realized as a Document Type Definition (DTD)

DAVE-ML: Dynamic Aerospace Vehicle Exchange markup language

- Developed as an XML-based pathfinder for engineering-level aerodynamic data
- Supports simple 1-D gridded up to n-D non-orthogonal tables
- Supports polynomial buildup equations
- Implements AIAA standards for aero data
  - Data and buildup equations
  - References to documentation (provenance)
  - Confidence intervals

F-16 aero model example

- F-16 aero model converted to XML by hand
- Captures Stevens & Lewis [1992] F-16 aerodynamic tables and buildup equations
- Based on M-script implementation by Morelli and Garza [2002]
- Set of XML tags from v1.4 of DAVE-ML DTD

F-16 model example (2/4)

F16_aero.xml excerpt

```
<!-- Function table lookup support variables -->

 <variableDef name="absbeta" varID="absbeta" units="deg">
   <description>
      Absolute value of angle-of-sideslip, deg.
   </description>
   <calculation>
     <math>
       <apply><abs/><ci>beta</ci></apply>
     </math>
   </calculation>
 </variableDef>

<!-- Breakpoint values -->

 <breakpointDef name="beta" bpID="BETA1" units="deg">
   <description>
      Angle-of-sideslip breakpoints for basic aero tables
   </description>
   <bpVals>
       0.0, 5.0, 10.0, 15.0, 20.0, 25.0, 30.0
   </bpVals>
 </breakpointDef>
```

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F-16 model example (3/4)

F16_aero.xml excerpt (cont'd)

```
<function name="Basic Cn">
   <description>
     Basic coefficient of yawing 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"/>
   </provenance>
   <independentVarRef varID="absbeta" min="0.0"   max="30.0" extrapolate="neither"/>
   <independentVarRef varID="alpha"   min="-10.0" max="45.0" extrapolate="neither"/>
   <dependentVarRef varID="absCn0"/>

<functionDefn name="Cn0_fn">
     <griddedTable name="Cn0_table">
   <breakpointRefs>
     <bpRef bpID="BETA1"/>
     <bpRef bpID="ALPHA1"/>
   </breakpointRefs>
   <dataTable> <!-- Note: last breakpoint (alpha) changes most rapidly
-10    -5     0     5    10    15    20    25    30    35    40    45         Alpha       -->
  0.,   0.,   0.,   0.,   0.,   0.,   0.,   0.,   0.,   0.,   0.,   0., <!-- |Beta| =  0. -->
.018, .019, .018, .019, .019, .018, .013, .007, .004,-.014,-.017,-.033, <!-- |Beta| =  5. -->
                                        [ snip ]
.079, .090, .106, .106, .096, .080, .068, .030, .064, .015, .011,-.001  <!-- |Beta| = 30. -->
       </dataTable>
     </griddedTable>
   </functionDefn>
```

F-16 results

- `F16_aero.xml` syntax validated successfully
- Used custom Java program, `DAVEtoSL`, to generate equivalent Simulink® MDL file
- Produces numerically-identical results as F-16 aero model from J. Davidson [2000] `gfsim`

Future Steps

- Finish XML realization of standard
  - Add check-case, time-history data formats
- Demonstrate model exchange between three sites
- Submit to AIAA; seek ANSI/ISO standard
- Develop model editor and report generator applications

Conclusions

- Substantial savings of time & effort clearly possible
- Model file serves as complete model archive
- Includes provenance, equations, data, statistics
- Applicable to automatic Monte Carlo studies
- Easy to grow and change as technology requires
- Early results demonstrate XML as candidate

Questions?

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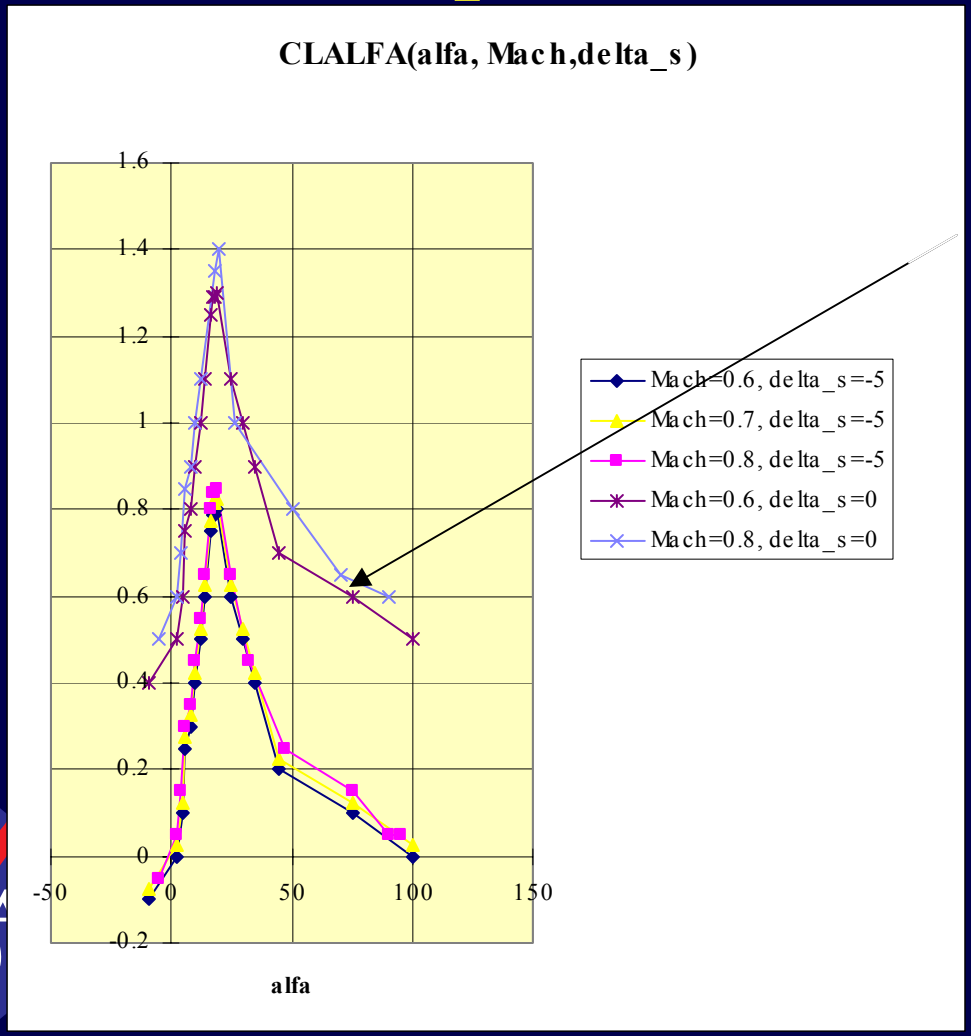
Function table with statistics and provenance



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