FACT: Enabling Systems Engineering as a Web Service

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- Novel methodology to help engineers and acquisition professionals
- Understand interactions and identify implications
- Systems of Systems Engineering
- Address Cost and Reliability, Maintainability and Availability
- Manage decision consequences
- Risk Management

FACT enables identification of $n^{th}$-degree effects of Design Decisions
• **Collaborative Development:** browser-based tool enables analysis as a web service

• **Performance:** “black box” approach to performance models integration through metadata interface

• **Cost:** acquisition cost estimating relationships and trusted O&S cost model

• **Model Based Sys Eng:** Leveraging SysML and accepted systems engineering standards

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**Dynamic Vehicle Comparison**

<table>
<thead>
<tr>
<th></th>
<th>Alternative 1</th>
<th>Alternative 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Land Range at Cruise</td>
<td></td>
<td></td>
</tr>
<tr>
<td>300.00</td>
<td>243.83 mi</td>
<td>409.58 mi</td>
</tr>
<tr>
<td>400.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Max Swim Speed</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6.00</td>
<td>7.89 mph</td>
<td>10.30 mph</td>
</tr>
<tr>
<td>12.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Max Water Speed at 1’ SWH</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8.19</td>
<td>3.47 knot</td>
<td>5.31 knot</td>
</tr>
<tr>
<td>17.48</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Minimum HP Required to Maintain</td>
<td></td>
<td></td>
</tr>
<tr>
<td>727.65</td>
<td>670.20 hp</td>
<td>603.21 hp</td>
</tr>
<tr>
<td>300.00</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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**Sensitivity & Confidence Analysis**

**Collaborative In- Browser 3-D Manipulation**
• The iterative process of engineering design followed by an analysis of cost and reliability is slow and inefficient.
FACT Architecture Goals

- Leverage DoD standards for discoverable and sharable data and services
- Services oriented approach for easy access and new functionality
- Unconstrained flexibility in model selection
- Effective configuration management to promote visibility of services and data via metadata standards
- Data sources and services pedigree according to VV&A best practices
- User Education on capabilities and technical foundations

Enable Systems Engineering as a Web Service
• **Scalability:** increasing numbers of concurrent users
• **Performance:** near real-time experience
• **Persistence:** future retrieval
• **Data homogenization:** standards-based approach
• **Computational engine:** agnostic to underlying models
• **Collaboration:** user’s viewing same data in real-time
• **Redundancy:** rapid access to data and backup
• **Client footprint:** (near-)zero client install

**Extensible framework allows for wide variety of applications**
System Properties as SysML Models

**Corresponding Vehicle Analysis**
- Identify Requirements
- Define Vehicle Specific WBS
  - Derive Cost Estimating Relationships (CER)
    - ID O&S Cost Model
  - Derive Sizing Rules
    - Derive Performance Rules
- Identify Trades of Interest

**FACT/SysML Integration**
- Create SysML Requirements Models
- Characterize WBS as SysML Block Definition Diagram
- Create SysML Parametric Models
  - Create new models
  - Wrap External Models
- Export XML data structure to Webserver
  - Develop GUI/Data Display Features
• Block Definition Diagrams used to represent physical decomposition as per MIL-STD-881A

• Parametric Diagrams capture performance relationships
Point Solution Configuration

- Configure systems from the “bottom up”
- Quickly assess impacts on metrics
Probability (PDF) and Cumulative Distribution Functions (CDF) quantify uncertainty of reaching thresholds and objectives.

- Subject Matter Expert distributions applied to variables of interest
- Monte Carlo Sampling
- Same SME inputs as Confidence Analysis
- Filter solutions “top down” by requirements
- Save configurations for comparison

Tradespace: Scatterplot

![Scatterplot Diagram]
Comparing System Alternatives

- Standard stoplight chart lists all requirements as rows and alternatives as columns
- Utilizes collaborative capability by updating requirement thresholds and objectives, alternative output metrics, and requirement importance in real-time

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Alternative 1</th>
<th>Alternative 2</th>
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</tr>
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<td>Minimum HP Required to Maintain S</td>
<td>727.65</td>
<td>300.00</td>
</tr>
<tr>
<td>Reserve Buoyancy</td>
<td>16.0k</td>
<td>20.0k</td>
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<tr>
<td>Swim Range (swim only)</td>
<td>100.00</td>
<td>150.00</td>
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<tr>
<td>Empty Mass</td>
<td>72.5k</td>
<td>67.5k</td>
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<tr>
<td>Gross Mass</td>
<td>80.0k</td>
<td>75.0k</td>
</tr>
</tbody>
</table>
• Government owned framework based on open source software and open standards
• Traceable capability across life cycle
• Trade space analysis during system concept development and guiding technology development
• Metadata to discover and leverage assets and to enhance interface interoperability
• Real-time decision maker collaboration
• Provides a basis to address the “should” and “will” cost questions
Conclusions

- Open architecture web service to provide rapid exploration of design tradespace
- SysML standard to characterize any system and process
- Collaborative web-browser framework for near real-time analysis
- Design parameter trades including performance, reliability, and cost of a system design
Next Steps

- Develop open source collaborative development framework
- Integration with Decision Component Registry modeling and simulation catalogue
- Apply open source distributed version control software and tools
- Apply methods and processes inherent within FACT beyond ground vehicles
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