Increasing Systems Engineering Efficiency for NASA’s Earth to Orbit Group and Sandia National Laboratory’s Recompression Closed Brayton Cycle Initiative with the Process Management Tool Vdot™

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Agenda

• Introduction
• Process Management With Vdot™
• NASA’s Earth to Orbit (ETO) Architecture Analysis
• Managing the ETO Architecture Analysis
• Sandia National Laboratory’s Recompression Closed Brayton Cycle Development and Commercialization
• Managing the Supercritical Transformational Energy Power (STEP) Initiative
• Conclusions
• Acknowledgements
• American engineer and social scientist Henry Laurence Gantt was the inventor of the Gantt chart, the most common form of showing a project plan and progress.

• The PERT (Program Evaluation and Review Technique) chart, conversely, is a pure logic representation of the project, with no time scaling, but with detailed logic relationships. Originally developed by the US Navy in the 1950s.

• However, most planning and execution software tools do not supply a real-time, critical path analysis, or the ability for the manager to quickly see a broad picture.
Introduction (Cont.)

How do you know…?

Visibility Challenges Cause Waste

Do Work
- Unnecessary Rework
- Late Deliveries
- Poor Info Handoffs
- Numerous Status Meetings
- Overloaded Resources
- Tribal Knowledge

Manager
- What is happening right now?
- What else should be happening now?
- Are we on schedule & budget?
- Are we following the plan?
- Do we need to change the plan?
- Are we meeting technical requirements?

Team Members
- What should I do next?
- What is the highest priority?
- When is it needed?
- How should I do it?
- Where is the data?
- Where did the data come from?
- Who needs my deliverables?
Introduction (Cont.)

The Plan

The Work

What limits visibility?

Management / Work Gap Limits Visibility
**Introduction (Cont.)**

How can we see where to go?

**Old Way – Paper Map**

Limitations:
- Static
- Best route unclear
- Can’t see traffic

**Ideal – Real-time GPS**

Advantages:
- Real-time / dynamic
- Turn by turn directions
- Traffic alerts

**Old Way – Gantt/Procedure/Spreadsheet**

Limitations:
- Static
- No Information flow
- Status outdated

**Ideal – Interactive Process**

Advantages:
- Real-time / dynamic
- Task by task directions
- Instant status visibility
Vdot™ Process Management

Kit for Tools

Work Instructions

Kit for Materials

How does Vdot Work?
Lean Factory “Kit” Analogy
Establish Requirements

Started: 03-04-2014
Done: 03-09-2014

MS Excel

Vdot™ “Smart Task Kits” Completely Define Activities

Everything Required for the Task at Hand at the Right Time
Vdot™ Process Management

Improve Project Planning, Execution, and Efficiency

Vdot Process Platform

Nest Your Processes

Embed Your Applications

Smart Task Flows

Visual Process Control

Connected to the Work

Real-Time Dashboards
Real-Time Dashboards for Managers
- Summarize team performance
- Drill down to individual performance
- Reflect work as it is performed
- Project Snapshots
- Gantt Charts
- Workloads
- Requirements

Task Lists for Team
- Gives task priority / schedule information
- Can launch tasks straight from list
- Reflects as-planned and as-changed work

Real-Time Information via the Web for All Participants
Example: 54% Cost Savings with Vdot™

- Process Improved/Automated: 18%
- Status Tracking Simplified: 16%
- Data Chase Eliminated: 9%
- Rework Reduced: 11%
- Monthly Cost

- 3 days: initial process capture
- 2 weeks: process improvements
- 3 months: project payback

Easy, Rapid Implementation. Dramatic Savings.
The ETO group is looking at various Space Launch System (SLS) heavy lift vehicle architectures, and is tasked to answer the questions: Will it work? What will it look like? What is the preliminary design?
The ETO SLS Evolvability Study Execution template was put into production in Nov 2013. This process template is repeatable and reusable for all ETO SLS study cases. Once activated, multiple Vdot study cases can run simultaneously. Example of one sequence where iterations are required is shown here.
Run times have improved from weeks to hours with Vdot. And the state of the data being analyzed is captured for each step in a database. The results of each ACO analysis are summarized in a “baseball card” showing the architecture of the mission. Productivity for these analyses has soared with the use of Vdot.

- As of 3/31/14
  - 485 Study Cases Completed
  - 132 Baseball Cards Generated
  - 19,000+ tasks executed in the system
Sandia took the lead in investigating the supercritical carbon dioxide (S-CO2) closed Brayton cycle (CBC) using internal research and development funds in 2007. Initial investigations focused on the stability of S-CO2 as a working fluid very near the fluid’s critical point – a thermodynamic state in which fluid properties vary dramatically.STEP is funded @$27.5M for FY15, S-CO2 @$57M.
The use of supercritical carbon dioxide can produce energy conversion efficiencies significantly higher than that for steam, the current standard working medium. Hence the push for commercialization efforts in parallel to the R&D.
DOE Standards Hierarchy

- DOE Policy
- Rules / Orders / Manuals
- Guides
- Standards

Directives System

Higher level safety criteria / objectives

Increase in implementation detail

Technical Standards Program
As the technology R&D moves toward the full validation of these features, the DOE has a very specific set of instructions that will guide the STEP program. Available online at www.directives.doe.gov, the document “Managing Design and Construction Using Systems Engineering” will be our guide.
STEP Systems Engineering Construct

Risk Analysis → Requirements Analysis & Documentation → Process & Program Management → TRL Tracking & Deliverables


Cradle Requirements Tool from 3SL

Vdot™ Process & Program Management Tool from ESI Group

Technology Program Management Model (TPMM) Sharepoint solution set from the US Space and Missile Defense Command, PARS II
ManagingSTEP Initiative (cont.)

The following representative table contains an example of the process steps required for a sample Critical Decision (CD). The process steps for each CD have been modeled in Vdot, and the overall top-level view of all the nested CDs is shown here.

<table>
<thead>
<tr>
<th>Prior to CD-1</th>
<th>Approval Authority</th>
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<tbody>
<tr>
<td>Complete a Conceptual Design</td>
<td></td>
</tr>
<tr>
<td>- Document High Performance and Sustainable Building provisions per EO 13442, Section 20, EO 13443, Section 2, and Sustainable Environmental Standards, and/or Technical Assistance provided by DOE O 430.2A, as amended, in the Conceptual Design Acquisition 5 matrix, and/or PEP, as appropriate. (Refer to DOE O 430.2A)</td>
<td></td>
</tr>
<tr>
<td>- Conduct a Design Review of the conceptual design with the project team</td>
<td></td>
</tr>
<tr>
<td>- For nuclear facilities, a Code of Record shall be initiated during the conceptual design.</td>
<td></td>
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<tr>
<td>- Complete a Conceptual Design Report. Refer to Appendix C, Preamble</td>
<td></td>
</tr>
<tr>
<td>Prepare a Preliminary Hazard Analysis Report (PHAR) for facilities that are not Category 5 nuclear facility (as defined in 10 CFR Part 820, Subpart B)</td>
<td></td>
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<tr>
<td>Establish a Quality Assurance Program (QAP). (Refer to 10 CFR Part 820, Subpart A-C, DOE O 414.1C, and DOE O 430.1-2-3.) For nuclear facilities, the applicable regulatory standard shall be NQA-1-2008 (Edition) and NQA-1-2008 (Editions).</td>
<td></td>
</tr>
<tr>
<td>Identify general Environmental and Safety requirements or the recommended site to DOE M 480.4-1 and DOE M 480.4-5.</td>
<td></td>
</tr>
<tr>
<td>Complete a National Environmental Policy Act (NEPA) Study by issuing an NOI (e.g., Environmental Assessment), as acquired by DOE O 431.1B. Prepare an Environmental Compliance Strategy, to include a schedule for timely acquisition of required permits and licenses.</td>
<td></td>
</tr>
<tr>
<td>Update Project Data Sheet or other necessary documents for ME and CE projects, if applicable. (Refer to OMB Budget Call for PDS and Exhibit A-500 Template)</td>
<td></td>
</tr>
<tr>
<td>For Hazard Category 3, 2, and 1 nuclear facilities, prepare a Safety Design Analysis with the concurrence of the OAS or with written advice of the SDA, as appropriate, projects subject to DOE-STD-1129-2008.</td>
<td></td>
</tr>
<tr>
<td>For Hazard Category 1, 2, and 3 nuclear facilities, conduct an Independent Peer Review (IPR) to ensure a smooth integration of safety into the design process. (Refer to DOE-STD-1129-2008)</td>
<td></td>
</tr>
<tr>
<td>Prepare a Conceptual Safety Design Report (CSDR) for Hazard Category 1, 2, and 3 nuclear facilities, including preliminary hazard analysis. For a project involving a major modification of an existing facility, the IPR must address the need for a CSDR, as well as the required PDSR. (Refer to DOECFDRC-008-00008-008)</td>
<td></td>
</tr>
<tr>
<td>Prepare a Conceptual Safety Validation Report (CSV R), with concurrence from the PDSR, or on the DOE review of the CSDR for Hazard Category 1, 2, and 3 nuclear facilities. (Refer to DOE-STD-1129-2008)</td>
<td></td>
</tr>
</tbody>
</table>

Nested process expanded for “Prior to CD-1” on next slide
The process steps for “Prior to CD-1” have been modeled in Vdot, as shown. This is an expansion from the nested process.
Conclusion

Vdot™ Bridges Plan/Work Gap

The Plan

The Work

Real-Time Visibility for the Entire Team in a Shared Environment
• NASA’s ETO Architecture Analysis benefits from Vdot by sequencing necessary tasks, deliverables, and team interactions required to produce quality products on time and within budget.

• The Sandia CBC demonstration project will see a set of macros that will work with a variety of commercially available tools to help automate, execute, and track the systems engineering process.

• Vdot™ provides an off-the-shelf platform to support automation of these and more scenarios allowing real-time, traceable collaboration between process participants.
The author would like to acknowledge Damian Yañez (with ESI Group North America) for his mapping of the DOE Acquisition Management process in Vdot, Linda Hudgins (Qualis Corporation) for her mapping of the ETO processes in the Vdot software platform, and Sue Delary (Qualis Corporation) for her thorough job of editing. Also, the author acknowledges the support and collaboration from Sandia’s Dr. Jim Pasch, S-CO2 Principal Investigator, and Gary Rochau, Manager, Advanced Nuclear Concepts, and acknowledge the support from Jay Newkirk, Executive Director of Energy Huntsville.