Overview of Engineering Design and Analysis at the NASA John C. Stennis Space Center

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SSC Regional Map
Complete Suite of Test Capability and Expertise

E-1 Stand
High Press., Full Scale
Engine Components

E-2
High Press.
Mid-Scale
& Subscale

E-3
High Press.
Small-Scale
Subscale

A-1 ... Full Scale Engine Devt. & Cert ... A-2

B-1/B-2 ... Full Scale Engine/Stage Devt. & Cert

Components ...Engines ... Stages
SSC Support Facilities

Cryogenic Propellant Storage Facility
Six (6) 100,000 Gallon LOX Barges
Three (3) 240,000 Gallon LH Barges

High Pressure Industrial Water (HPIW)
330,000 gpm Delivery System

High Pressure Gas Facility (HPGF)
(GN, GHe, GH, Air: ~ 3000 to 4000 psi)

Additional Support
• Laboratories
  ✓ Gas and Material Analysis
  ✓ Measurement Standards and Calibration
  ✓ Environmental
• Shops
• Utilities
Propulsion Testing at the NASA John C. Stennis Space Center (SSC)

Video
NASA SSC Design & Analysis Division

Design and Analysis Division

- Configuration Management
- Records Retention DB Management

Mechanical and Component Systems
- Cryogenic Propellant Systems
- Storable Propellant Systems & HPIW
- Hydraulics/pneumatics Systems
- Press Gas/Purge Systems (TBA)
- Components
- Materials
- Ancillary Systems
  - TMS, Measurement Uncertainty
  - Standards & Specifications

Electrical Systems & Software
- Data Acquisition
- Instrumentation & Signal Conditioning
- Controls & Simulation
- DACS Lab Management
- Data Systems Management
- Ancillary Systems/Electrical Power

Systems Analysis & Modeling
- Modeling and Analysis development and integration into RPT
- Fluid Mechanics/Thermal Analysis of Propellant Systems
  - Liquid
  - Gas
- CFD
- Structures/Loads Analysis
- Thermal/Heat Transfer Analysis

Organization Goal:
- Develop and maintain propulsion test systems and facilities engineering competencies
  - Unique and focused technical knowledge across respective engineering disciplines applied to rocket propulsion testing. e.g.,
    - Materials selection and associated database management
    - Piping, electrical and data acquisition systems design for cryogenic, high flow, high pressure propellant supply regimes
    - Associated analytic modeling and systems analysis disciplines and techniques
    - Corresponding fluids structural, thermal and electrical engineering disciplines
Integrated Facility Simulation and Analysis

- To Support Propulsion Testing, SSC Has Developed & Implemented Analytic Modeling & Simulation Tools
  - Rocket Propulsion Test Analysis (RPTA) Model (FORTRAN) Used to Simulate Propulsion Test Facility Systems (e.g., LOX Run System)
    - Heritage of Model Dates to Pressurization and Propellant Systems Design Tasks for Space Shuttle and X-33
    - Model Adapted, Validated and Currently Used at SSC to Simulate Facility Pressurization and Propellant Systems
  - Computational Fluid Dynamics (CFD) Used for Select Propulsion Test Situations
  - Have Experienced Analysis Team that Routinely Solves Pressurization and Propellant System Problems
- Integrated Facility Simulation and Analysis Has Led to Substantial Project Cost and Schedule Savings
Integrated Facility Simulation and Analysis

- Analytic Tools Available for Propulsion Test Facility Modeling & Analysis
- Comprehensive Propellant System Thermodynamic Modeling & Test Simulation

Integrated Performance Modeling Capabilities Substantially Improves Understanding & Knowledge of Test Systems Performance that has Translated to Efficient Test Facility Design, Activation & Test Operations

Test and Data Analysis

Advanced Capabilities in CFD Modeling & Analysis
Rocket Propulsion Test Analysis (RPTA) Model

- Temporal Transient Thermodynamic Modeling of Integrated Propellant Systems
- Thermodynamic Control Volume Solver Model Accurately Models High-Pressure Cryogenic Fluids and High-Pressure Gaseous Systems. Model Features Include:
  - High-Fidelity Pressure Control Valve (PCV) & Closed Loop Control System Model
- RPTA Model Validated Through Test Data Comparisons
  - IPD Fuel Turbopump, RS-84 Sub-Scale Pre-Burner, RS-83 Pre-Burner Cold Flows, SSME Flowliner Activation & IPD Engine System

Pressure Control Valve (PCV) Model Developed & Validated

A Significant Advantage of the RPTA Model is the Coupling of Control Logic (Electro-Mechanical Process) with Thermodynamic Processes
Recent LOX/Methane Testing at E-3
15 klbf Advent Engine Test Program – Nov 06

Facility Activated and Test Performed

- Liquid Methane (LM) & Liquid Oxygen (LOX) Propellants Used
- Facility Model Results and Facility Test Activation Results Agree Well
- Test Capability: ~25 seconds
Comprehensive & Rapid Piping System Design & Analysis Capability

- Commercial Tools Employed to Augment Analysis
- Example: FlowMaster Piping System Analyzer
  - Allows for Steady-State or Transient Analysis, Compressible or Non-Compressible Flow
  - Includes Heat Transfer, Flow Balancing, Priming & Sizing Analysis

Water Hammer Effect Due to Rapid Closure of Main Fuel Valve

Propellant Flow to Test Article Due to Rapid Opening of Main Fuel Valve
Recent Project: Methane Technology Testbed Project (MTTP)

- MTTP provides portable, small-scale propulsion test capabilities
  - Can support gaseous methane, gaseous oxygen, liquid methane and kerosene-type propellants
  - Capable of supporting engines up to 1000-lbf thrust
- Tested 50-lbf thruster (right)
  - Plume diagnostics
  - Gained methane experience

Night firing of MTTP thruster

Exhaust spectrum for GOX/GM combustion
Recent Project: 14” Valve Test
Description of Test Objectives

Test Objectives

• Collect Data Needed to Support a Decision to Install a 14” Valve (26,000 lb) on the E-1 Test Stand as the High Pressure (8,500 psi service) LOX Tank Isolation Valve
• Determine the Behavior of the Valve in Simulated Operating Conditions
• Determine the 14” Valve Bonnet and Body Steady State Temperatures

Test Details

• Conducted Valve Chill Down Test at the E-2 Test Stand
• Used Liquid Nitrogen (LN) to Chill Down the Valve
• Instrumented Valve with Multiple Thermocouples on the Valve Body and Stem
• During Chill Down Operations, the Valve was Cycled Multiple Times to Test Proper Valve Operation at Low Temperatures

14” Valve During Chill Down
14” Valve Test Results

Test Results
• Test Lasted About 24 Hours
• About 6500 gal of LN Was Used for the Valve to Reach a Steady State Condition
• Boil Off Results Were Used to Calculate the Steady State Heat Load of the Valve

Analytical Accomplishments
• Identified Issue with Asymmetric Bonnet Wear at Cryogenic Temperatures
• Verified Analytical Predictions for the Heat Load of the Valve
  – Determined the Valve Heat Load
  – Determined the Valve Chill Down Time Constant
  – Test Results Will Be Used to Guide Bonnet Re-Design
14” Valve
ANSYS Workbench Thermal Simulation

Geometry Description
Pro-E Solid Model

Analysis Model
3-D ANSYS Finite Element Model:
275,000 Nodes
185,000 Elements

Loads & Boundary Conditions
Radiation
Natural Convection
Boiling Convection

Validated Results
Measured Steady-State Frost Line
Measured Valve Heat Load: 9308 BTU/Hr

Predicted Steady-State Frost Line
Predicted Valve Heat Load: 9315 BTU/Hr

NIST / MIL-HDBK Temperature Dependent Material Properties

Empirically Based Temperature Dependent Boundary Condition Parameters
Convective Film Coefficient for Natural Convection of Air over Horizontal Cylinder
Boiling LN2 Convective Film Coefficient

Geometry
Description
Loads & Boundary
Conditions
Validated Results

Analysis
Model

Von-Mises Stress
Total Deformation
Deformation @ 89X
Computational Fluid Dynamics (CFD) Modeling

Employed CFD Code to Model E-1 High Pressure LOX Flow Capability

- CFD Investigations Indicate Pressurizing Gas Diffuser Flow Significantly Limits Flow Duration for High Flow Rate Cases

Analysis Boundary Conditions

- HP LOX Tank at E-1 Test Stand
- Flow Case Assessed
  - 2500 lb/sec LOX Discharge Rate
  - 8400 psi Tank Pressure Maintained During Propellant Discharge

Results & Observations

- GN Convective Mixing with LOX Propellant is Substantial
  - Only 50% Loaded LOX is Useable (<~2% N₂ Concentration)
- LOX Propellant Supply at Assessed Flow Rate & Pressure Limited to Approximately 4 seconds (vs an Estimated 10 seconds Determined Using Nominal Facility Pressurizing Gas & Propellant Supply Limits)
Computational Fluid Dynamics (CFD) Modeling

- Understanding a Valve’s Flow Capacity ($C_v$) as a Function of Valve Stroke is Critical When Calculating the Propellant Flow Rates to a Test Article

2.75” Stroke

3.25” Stroke

3.75” Stroke

Velocity & Streamlines

Pressure

LOX Control Valve $C_v$: Predicted and Experimental

- CFD Used to Predict the Flow Field & $C_v$ Curve for a Modified LOX Control Valve
- Yields a Good Understanding of How the Flow Field Changes as the Valve Opens & Affects $C_v$ curve
- Analysis Reveals Areas Where Cavitation May Occur as Well as Areas of High Velocity That Are Important When the Working Fluid is LOX
Thermal Fatigue Considerations

• The Goal of This Investigation Was to Simulate the Thermal Environment During Tank Chill Down and Apply What Was Learned in the Specimen Testing to Improve the Reliability of Analytical Model Calculations

• Performed Laboratory-Scale Testing

**Test Specimen**

• 5 Thermocouple & Strain Gage Pairs - 4 on 8” dia Spaced at 90°, 1 at Center. Typical on Both Top & Bottom Surface.

• Total of 20 sensors

**Test Procedure**

• Subject Top of Test Specimen to LN

• Record Strain & Temperature Data

• NDE Dye Penetration Test Performed for Crack Detection

• Testing for Crack Initiation Made After Each Thermal Cycle for the First 15 Cycles

• Subject Test Specimen to Greater Than 100 Cycles
**Thermal Fatigue Considerations**

**Top Center Temperature & Compensated Strain**

- Initial Cold Shock Leads to Largest Strain Due to Maximum Temperature Difference

Lab-Scale Specimen Exposed to LN
Summary

• SSC has Developed a Suite of Effective Analytic Modeling and Analysis Tools Providing High Fidelity Assessment of Test Stand Performance
  – Rocket Propulsion Test Analysis (RPTA) Model, a 1-D Propellant System Analyzer
  – CFD Applied to Select Propulsion Test Situations
  – Finite Element Analysis (ANSYS/CFX)
• Analytic Tools Exercised Regularly on a Variety of Propulsion Test Projects by Experienced Analysts
  – Active Test Facilities (1.0 to 1.5 Mlbf Thrust, 8500 psi LOX/LH/RP-1 Supply)
  – Active Test Projects (e.g., J-2X PPA, J-2X at PBS, TGV)
• We are Planning to Augment our Staff
  – Fluid Mechanics/Systems Modeling & Analysis
  – Thermal Analysis

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Facilities & Operations

SSC’s ETD (Engineering and Science Directorate) manages, develops, and operates SSC Rocket Propulsion Test (RPT) capabilities and facilities.
Complete Suite of Test Capability and Expertise

E-1 Stand
High Press., Full Scale Engine Components

E-2
High Press.
Mid-Scale & Subscale

E-3
High Press.
Small-Scale Subscale

A-1 … Full Scale Engine Devt. & Cert … A-2

B-1/B-2 … Full Scale Engine/Stage Devt. & Cert

Components … Engines … Stages
Component and Engine Testing (E-1)

- High Pressure (Long Run) Capabilities
  - LOX/LH/RP ~ 8,500 psi
  - GN/GH ~ 15,000 psi
  - GHe ~ 10,000 psi

- State-of-the-Art DAC Systems

- E-1 Cell 1
  - Primarily Designed for Pressure-Fed LOX/LH/RP & Hybrid Test Articles
  - Thrust Loads up to 750K lb$_f$ (horiz.)

- E-1 Cell 2
  - Designed for LH Turbopump & Preburner Assembly Testing
  - Thrust Loads up to 60K lb$_f$

- E-1 Cell 3
  - Designed for LOX Turbopump, Preburner Assembly & Engine Testing
  - Thrust Loads up to 750K lb$_f$
Full-scale Engine Development & Certification

- Saturn V 2nd Stage J-2 engine (1.15 M-lbf cluster of 5 LH₂/LOX J-2 engines)
- SSME (375 K-lb LH₂/LOX) development, flight acceptance, & 65kft altitude (A-2)
- X-33 Aerospike

TEST STAND CAPABILITIES:
- Thrust capability of 1.5 M-lbf
- Flame Deflector Cooling 220,000 gal/min
- Deluge System 75,000 gal/min
- Data measurement system
- Two derricks – 75 ton and 200 ton
- High-pressure gas distribution systems
- LOX and LH2 propellant supply systems
- Hazardous gas and fire detection systems
- Barge unloading capability (2 LOX, 2 LH)
- Diffuser (A-2)
Vehicle Stage & Full-scale Engine Testing

- SATURN V (7.7 M-lbf cluster of 5 RP-1/LOX F-1 engines)
- SSME MPTA (1.1 M-lbf cluster of 3 LH₂/LOX SSME)
- Delta IV Common Booster Core (650 K-lbf LH₂/LOX RS-68 engine)

TEST STAND CAPABILITIES:
- Thrust capability of 13 M-lbf
- Flame Deflector Cooling 330,000 gal/min
- Deluge System 123,000 gal/min
- Data measurement system
- Two derricks – 175 ton and 200 ton
- High-pressure gas distribution systems
- LOX and LH2 propellant supply systems
- Hazardous gas and fire detection systems
- Barge unloading capability (3 LOX, 3 LH)
NASA SSC Design & Analysis Division

Design and Analysis Division
- Configuration Management
- Records Retention DB Management

Mechanical and Component Systems
- Cryogenic Propellant Systems
- Storable Propellant Systems & HPIW
- Hydraulics/pneumatics Systems
- Press Gas/Purge Systems (TBA)
- Components
- Materials
- Ancillary Systems
  - TMS, Measurement Uncertainty
  - Standards & Specifications

Electrical Systems & Software
- Data Acquisition
- Instrumentation & Signal Conditioning
- Controls & Simulation
- DACS Lab Management
- Data Systems Management
- Ancillary Systems/Electrical Power

Systems Analysis & Modeling
- Modeling and Analysis development and integration into RPT
- Fluid Mechanics/Thermal Analysis of Propellant Systems
  - Liquid
  - Gas
- CFD
- Structures/Loads Analysis
- Thermal/Heat Transfer Analysis

Organization Goal:
- Develop and maintain propulsion test systems and facilities engineering competencies
  - Unique and focused technical knowledge across respective engineering disciplines applied to rocket propulsion testing. e.g.,
    - Materials selection and associated database management
    - Piping, electrical and data acquisition systems design for cryogenic, high flow, high pressure propellant supply regimes
    - Associated analytic modeling and systems analysis disciplines and techniques
    - Corresponding fluids structural, thermal and electrical engineering disciplines
Integrated Facility Simulation and Analysis

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    ✓ Heritage of Model Dates to Pressurization and Propellant Systems Design Tasks for Space Shuttle and X-33
    ✓ Model Adapted, Validated and Currently Used at SSC to Simulate Facility Pressurization and Propellant Systems
  – Computational Fluid Dynamics (CFD) Used for Select Propulsion Test Situations
  – Have Experienced Analysis Team that Routinely Solves Pressurization and Propellant System Problems

• Integrated Facility Simulation and Analysis Has Led to Substantial Project Cost and Schedule Savings
D&A Capability Development

**Strengthening Engineering Competencies**
- Structural Analysis
- Control Systems design/development
- Thermal Analysis/Heat Transfer
- Fluid Mechanics specific to RPT

**Analysis Tool Suite Growth**
- Structural Analysis
  - ANSYS/CFX
- Purge systems design and analysis
  - Flowmaster
- Structural Heat Transfer/Thermal Analysis
  - SINDA
- Piping system modal analysis
  - Autopipe

**SSC Design & Analysis Division**
- RPTA Model
- CFD Crunch/FDNS
- MathCad/Excel Models

**Comprehensive Test Site Engineering Support**
- A,B & E Stand Modeling & Analysis
  - J-2X, A3, Subscale Sim, Steam Gen Projects
- Operations Support
  - Test stand activation & test
- Facility Operations Support, e.g.,
  - LO2 Barge Impeller Structural Margin Def.
  - A1/A2 LH2 Vent Duct Rupture Invest, and Resolution
  - HPGN system redesign
  - HP Air System Contamination
  - LH2 Sphere Bypass Design
  - UT inspection of B Stand HP Water Deluge Sys

**Expanding Beyond SSC E-Complex**
- Ares US Propellant Tank Operations Performance Analysis Support to MSFC
- PBS B2 Test Stand Design
- RS-68 Test vs Flight Performance
- LSAM (JSC) & CEV SBT (GRC/NESC)

**Data Analysis Process Improvements**
- Design & Data Management System
  - Record Retention System
  - Drawing Tree Development
  - Pro/E model MSK capability
    - A CM enhancement opportunity
- Wider access to analytic models
  - PSME Project
  - Server Access
- Internal Technical Reviews

**Expanding Beyond SSC E-Complex**
Integrated Facility Simulation and Analysis

- Analytic Tools Available for Propulsion Test Facility Modeling & Analysis
- Comprehensive Propellant System Thermodynamic Modeling & Test Simulation

Integrated Performance Modeling Capabilities Substantially Improves Understanding & Knowledge of Test Systems Performance that has Translated to Efficient Test Facility Design, Activation & Test Operations

GH2 Activation Test
June 29, 2004

Advanced Capabilities in CFD Modeling & Analysis
Rocket Propulsion Test Analysis (RPTA) Model

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Pressure Control Valve (PCV) Model Developed & Validated

A Significant Advantage of the RPTA Model is the Coupling of Control Logic (Electro-Mechanical Process) with Thermodynamic Processes
Comprehensive & Rapid Piping System Design & Analysis Capability

- Commercial Tools Employed to Augment Analysis
- Example: *FlowMaster* Piping System Analyzer
  - Allows for Steady-State or Transient Analysis, Compressible or Non-Compressible Flow
  - Includes Heat Transfer, Flow Balancing, Priming & Sizing Analysis

**Water Hammer Effect Due to Rapid Closure of Main Fuel Valve**

**Propellant Flow to Test Article Due to Rapid Opening of Main Fuel Valve**

Fluid = RP-1
Flow Rate = 90 lbm/s
Steady-State Node Pressure Shown (PSIA)
Facility Activated and Test Performed

- Liquid Methane (LM) & Liquid Oxygen (LOX) Propellants Used
- Facility Model Results and Facility Test Activation Results Agree Well
- Test Capability: ~25 seconds
14” Valve
ANSYS Workbench Thermal Simulation

Geometry Description
- Pro-E Solid Model

Analysis Model
- 3-D ANSYS Finite Element Model: 275,000 Nodes, 185,000 Elements

Loads & Boundary Conditions
- Radiation, Natural Convection, Boiling Convection

Validated Results
- Measured Steady-State Frost Line
- Predicted Steady-State Frost Line
- Predicted Valve Heat Load: 9315 BTU/Hr
- Measured Valve Heat Load: 9308 BTU/Hr

NIST / MIL-HDBK Temperature Dependent Material Properties

Empirically Based Temperature Dependent Boundary Condition Parameters
- Boiling LN2 Convective Film Coefficient
Analysis Boundary Conditions
• HP LOX Tank at E-1 Test Stand
• Flow Case Assessed
  – 2500 lb/sec LOX Discharge Rate
  – 8400 psi Tank Pressure Maintained During Propellant Discharge

Results & Observations
• GN Convective Mixing with LOX Propellant is Substantial
  – Only 50% Loaded LOX is Useable (<~2% N\textsubscript{2} Concentration)
• LOX Propellant Supply at Assessed Flow Rate & Pressure Limited to Approximately 4 seconds (vs an Estimated 10 seconds Determined Using Nominal Facility Pressurizing Gas & Propellant Supply Limits)
Advanced CFD Capability

• Employ CFD Techniques to Support Propulsion Testing in the Following Areas:
  – Cryogenic Propellant Delivery Systems (e.g., Run Tanks, Piping)
  – Cryogenic Control Devices (e.g., Valves)
  – Plume Modeling

• Dedicated Computational Cluster (48 Dual Processors) at NASA SSC

Computational Results of Conceptual Ares 5 Stage Test at SSC B-2 Test Stand

ARES I

Computational Results of J-2X Altitude Diffuser Simulation (300 K-lbf)
CFD data was used to support parallel efforts in the experimental plume diagnostics and line-by-line spectral radiation analysis.

**Experimental Variation in Spectral Emissions with O/F Ratio**

- **CH (0,0) Band**
- **CH 3900 Å Band**
- **C₂ Swan Band**
- **C₂ Swan Band**

*Courtesy of Lester Langford NASA SSC*

**Line-by-Line Hydrocarbon Spectral Calculations**

*Courtesy of Gopal Tejwani NASA SSC*
Summary

- SSC has Developed a Suite of Effective Analytic Modeling and Analysis Tools Providing High Fidelity Assessment of Test Stand Performance
  - Rocket Propulsion Test Analysis (RPTA) Model, a 1-D Propellant System Analyzer
  - CFD Applied to Select Propulsion Test Situations
  - Finite Element Analysis (ANSYS/CFX)
- Analytic Tools Exercised Regularly on a Variety of Propulsion Test Projects by Experienced Analysts
  - Active Test Facilities (1.0 to 1.5 Mlbf Thrust, 8500 psi LOX/LH/RP-1 Supply)
  - Active Test Projects (e.g., J-2X PPA & Engine, A-3, Chemical Steam Generator)

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Liquid Propellant System Modeling

Summary

Background

• The Rocket Propulsion Test Analysis (RPTA) Model is an effective analytic modeling and analysis tool providing high fidelity assessment of propellant system performance
  – RPTA adapted from a model originally developed for Shuttle & X-33 propellant system performance analyses
  – RPTA model application:
    • Used extensively for
      • SSC propellant system analysis (e.g., test project (e.g., J-2X PPA, A-3, chemical steam generator (CSG)) facility development, activation
      • Test and facility maintenance and upgrades investigations, studies and trades
      • Recently used for systems sizing and operations performance analysis of the LOX and LCH4 tanks for the lunar surface ascent module team study (May 2007)
      • Currently being employed to evaluate propellant load operations and performance of the Ares I LOX & LH tank for MSFC team (January 2009)

  – A graphical user interface (GUI) developed for the RPTA model to allow ease of use of the model

Benefits

• Propellant system modeling allows for a timely & cost-effective assessment of the propellant system performance

• Integrated performance modeling capabilities has translated to efficient test facility design, activation & test operations
Integrated Facility Simulation and Analysis

- Analytic Tools Available for Test Facility/Project Modeling & Analysis
- Comprehensive Propellant System Thermodynamic Modeling & Test Simulation

Integrated Performance Modeling Capabilities Substantially Improves Understanding & Knowledge of Test Systems Performance that has Translated to Efficient Test Facility Design, Activation & Test Operations

System Design

UHP GH2 Bottles
- 625 ft³ 15,000 psig
- 625 ft³ 15,000 psig
- 625 ft³ 15,000 psig

To HP Flare

MV 10A186 GH

FCV 10A29 GH

MV 10F22 GH

To HP Flare

MV 10F22 GH

MV 10F21 LH

To Cell 3

MV 10A1402 LH

GF 10A4255 LH

Integrated Performance Modeling

GH2 Activation Test
June 29, 2004

Test and Data Analysis

UHP Bottle Pressure

Mixer Pressure

Interface Pressure

Distance from Discharge (ft)

20 mph Wind

Advanced Capabilities in CFD Modeling & Analysis

Fluid System Modeling

NASA/SSC/EA30
01/21/09
Rocket Propulsion Test Analysis (RPTA) Model

- Temporal Transient Thermodynamic Modeling of Integrated Propellant Systems
  - Thermodynamic Control Volume Solver Model Accurately Models Cryogenic and Storable Propellant and High-Pressure Gaseous Systems.
  - Includes High-Fidelity Pressure Control Valve (PCV) & Closed Loop Control System Algorithms

- Model Validated Through Numerous Test Data Reconstructions
  - J-2X PPA-1A, IPD Fuel Turbopump, RS-84 Sub-Scale Pre-Burner, RS-83 Pre-Burner Cold Flows, SSME Flowliner Activation & IPD Engine System

Pressure Control Valve (PCV) Model Developed & Validated

A Significant Feature of the RPTA Model is the Coupling of Control Logic (Electro-Mechanical Process) with Thermodynamic Processes
RPTA Model GUI Development

Background

• The RPTA Model provides focused and detailed analysis of a propellant system, from a single propellant tank to an integrated propellant system that includes
  – Propellant Tank
  – Facility Propellant Storage Tank
  – Pressurant Supply and System Control
  – Propellant Feed System
  – Test Article Simulation

• Requires a substantial amount of data defining boundary and initial conditions that requires esoteric knowledge of the model’s data file structure and the model’s code not required of the typical user
  – Following is a quick view of the model parameter data sets involved
GUI interface Significantly Simplifies Model Set-up
Provides Access to All Configuration Data

Model Configuration Files

$DATA
IN_OUTPUT=TANKMDF.DAT
IN_TABLES=TABLES.DAT
LOG=F
LIGGER=F
PDIV=0.33, 0.33, 0.6, 0.6, 0.33, 0.33, 0.6, 0.33,
WDHEI=0.
!ACOEFF=0.09, 0.12, 0.23, 0.10, 0.13, 0.13, 3.70, 0.06,
TAN=30.
!VOLSPH=5611.9765450645
ACOEFF=0., 0.0, 0.0, 0.0, 0.0, 0.0, 0.0,
ADIF=0.555
ALT=0.
ATOM=0.0023
BOTMAT=3
BUBV=0.
CRAD=0.0000000000000384
DGHEBTL=135.282990179341
GHEBTL=1002.
DIAL=4.04,10.,
DROP=0.
DVDT=0.
GAMMA=1.4
IGAS=5
PRTHICK=2.25
IN_TANK="RUNTABLES.dat"
IRPLOT=0
LHEAT=F
LPAP=F
LSPL=F
MCDTBE=0

OK  Cancel
Model Execution & WinPlot Results

WinPlot 4.40
Edit w/menu Nomenclature->Set Title

PT
Tank pressure (absolute)

Control Valve
PLC Control

Test Conditions
Trajectory Data

Run
View Results

Push button to stop

11/4/2006 1:10:41 PM
A3_CSG_IPA
Liquid

Save Changes
View Configuration Files
MCM Admin
Exit
Propellant Systems Modeling Environment
Model Library & Configuration Editor

Interactive Schematic Integration Prototype

Created by SSC RPT Engineer Expertise;
Predefined Liquid Propellant Models for Specific Test Facilities are Baseline.

The Engineer’s Model Revisions are Managed in a Familiar Tree Structure Format.
Propellant Systems Modeling Environment

Gas Model Support Scheduled in Early 2009

Propellant-Aware, PSME Detects Whether Model Selections are Liquid or Gas and Serves up the Correct Executable and Parameter Editing Screens to the Engineer.

<table>
<thead>
<tr>
<th>Home</th>
</tr>
</thead>
<tbody>
<tr>
<td>TEST CONDITIONS (G)</td>
</tr>
</tbody>
</table>

- Trajectory.csv
- VALL_DATA.dat
- Gas-Output.vpl

PSME Provides Automated Validation Checking of Parameter Fields with Defined Value Types and/or Min / Max Ranges for Both Liquid and Gas.
SSC Engineering & Test Directorate (ETD)

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