SAND2005-7839P

SIERRA/Fuego/Syrinx Overview

Stefan P. Domino, SIERRA/Fuego/Syrinx PI
Thermal/Fluid Computational Engineering Sciences, 1541

FY06 LII V&V Milestone Review
January 16th-17th, 2006
Albuquerque, NM

Sandia is a multiprogram operated by Sandia Corporation, a Lockheed Martin Company for the United States Department Of Energy's National Nuclear Security Administration under Contract DE-AC04-94AL85000.

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Presentation Outline

- What is SIERRA/Fuego/Syrinx and What are its' Core Capabilities
- Coupling Strategy
- SIERRA Framework
- Numerical Overview
- SIERRA/Fuego Presentations to Come
    - Code Documentation
    - Software Quality Engineering
    - Code Verification

Characterize Abnormal Environments

- **Predict thermal loads to objects in and around fire**
- **Order (minutes:hours) of m-n-t**
- **Model interaction between objects and the fire**
- **Predict heat transfer within objects in the fire**

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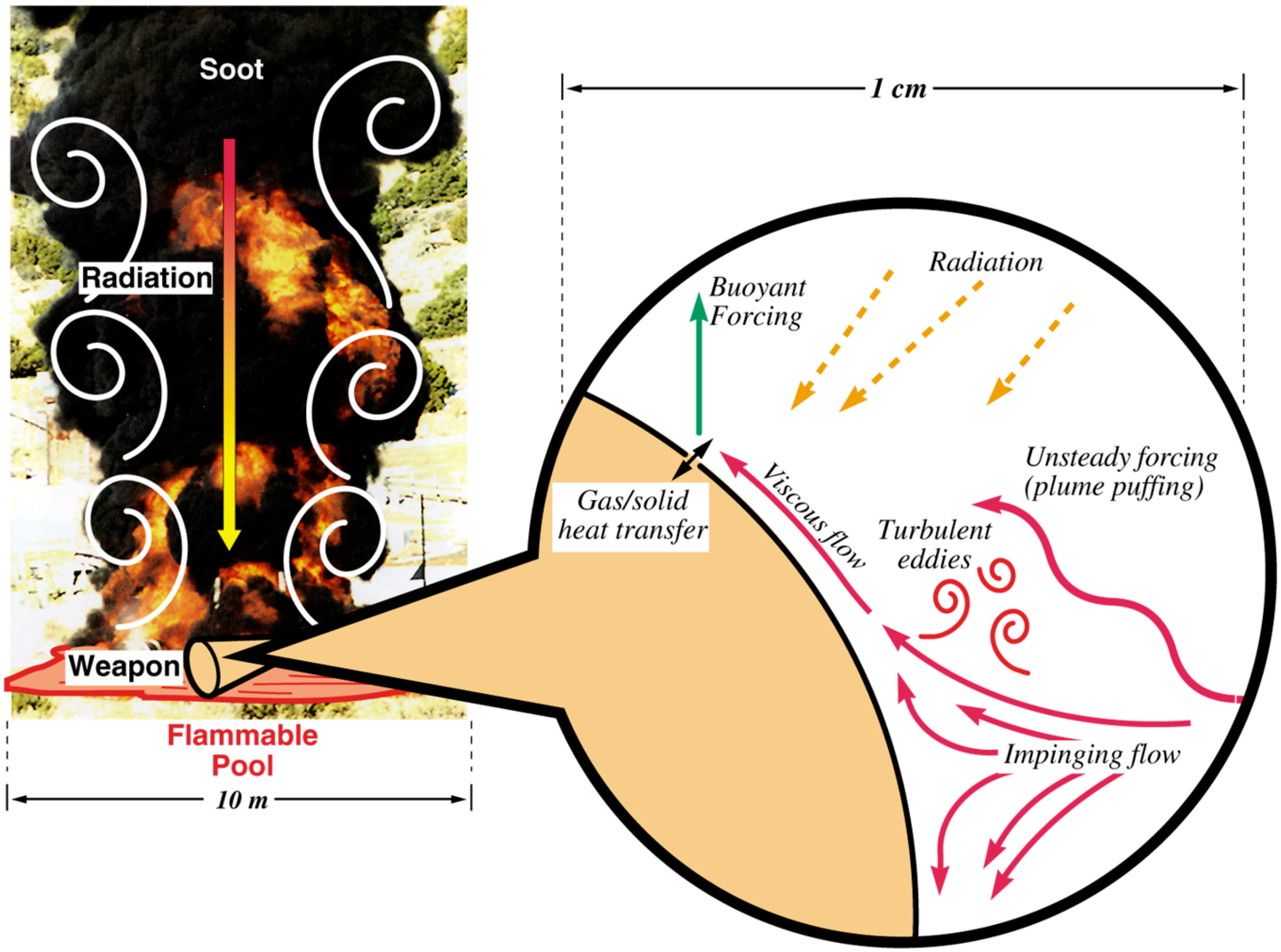
ADVANCED SIMULATION & COMPUTING

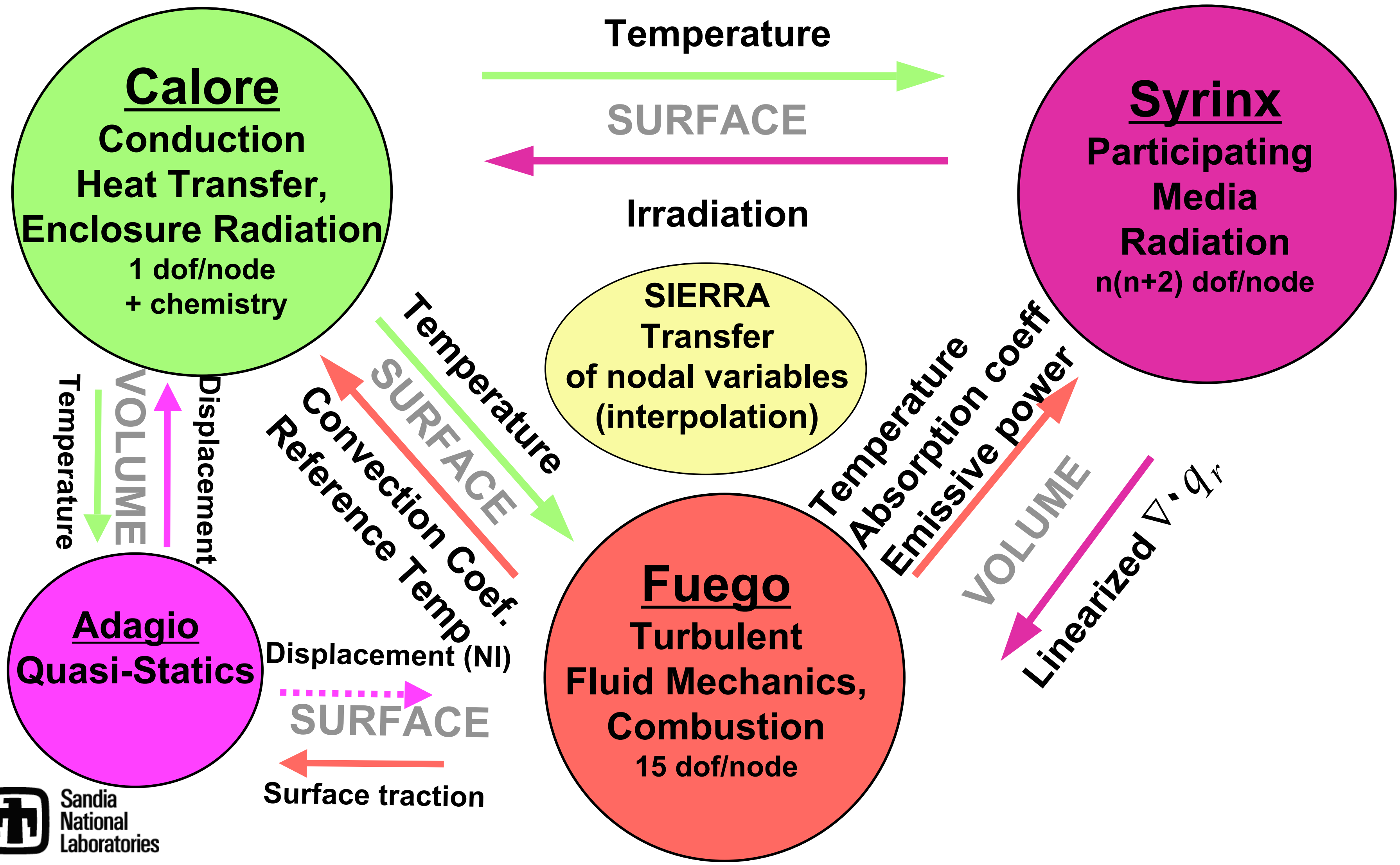
Heat Transfer Modes in a Fire



Phenomena Identification and Ranking Table (PIRT) give the following ranking
- **Radiation**
- **Convection**
- **Conduction**

Radiation and convection are strongly affected by turbulent fluid mechanics

Coupled-Mechanics
Object-in-Fire with Structural Response



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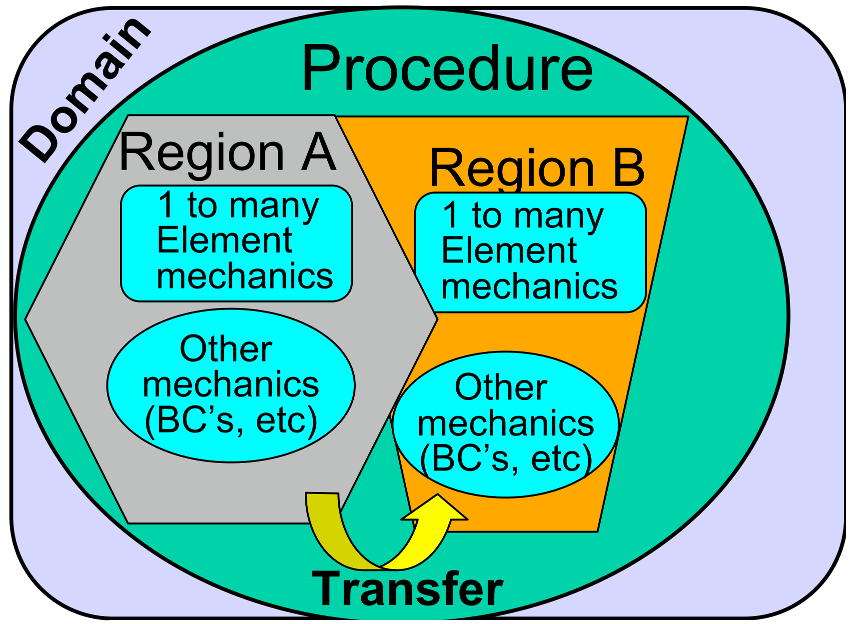
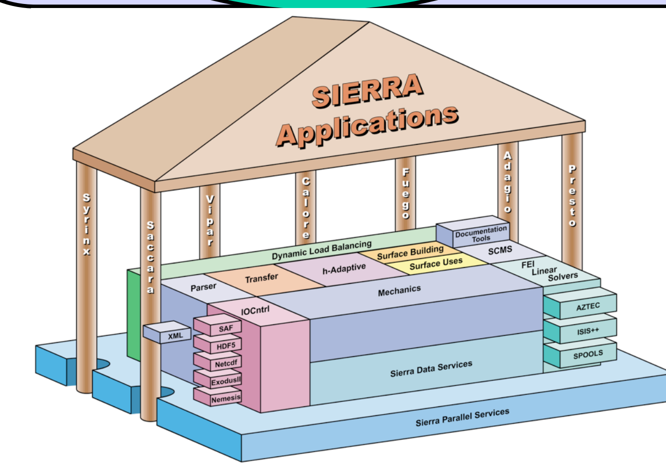
ADVANCED SIMULATION & COMPUTING

SIERRA/Fuego/Syrinx/Calore Methodology and Framework Supports

- **SIERRA/Fuego: low Mach number turbulent, reacting code with unstructured heterogeneous topology mesh (hex, tet, wedge, pyr) support.**
  - **Combines finite-volume method (FVM) and the finite-element method (FEM), CVFEM**
- **SIERRA/Syrinx: Participating media radiation (PMR) using the method of discrete ordinates.**
  - **•Streamwise-Upwind Petrov-Galerkin FEM approach**
- **SIERRA/Calore: heat conduction with contact resistance, adaptivity, enclosure radiation, and chemistry**
  - **Galerkin FEM**





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Each code has defined and completed a detailed verification suite!

Fluid Mechanics Math Models

- low Mach number formulation (CVFEM discretization); unity Le
- 15 equations for combustion with soot transport
- can configure subset of equations including laminar variants

Modeled terms

$$\int \frac{\partial \bar{\rho}}{\partial t} \mathrm{d}V + \int \bar{\rho} \tilde{u}_j dn_j = 0$$

$$\int \frac{\partial \bar{\rho} \tilde{u}_i}{\partial t} \mathrm{d}V + \int \left(\bar{\rho} \tilde{u}_i \tilde{u}_j + p \delta_{ij} \right) dn_j = \int \left(\bar{\tau}_{ij} - \overline{\rho u_i'' u_j''} \right) dn_j + \int \left(\bar{\rho} - \rho_o \right) g_i \mathrm{d}V$$

Buoyancy source term

$$\int \frac{\partial \bar{\rho} k}{\partial t} \mathrm{d}V + \int \bar{\rho} \tilde{u}_j k dn_j = \int \frac{\mu_t}{\sigma_k} \frac{\partial k}{\partial x_j} dn_j + \int \left(P_k - \rho \varepsilon \right) \mathrm{d}V$$

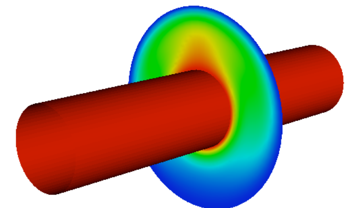
$$\int \frac{\partial \bar{\rho} \varepsilon}{\partial t} \mathrm{d}V + \int \bar{\rho} \tilde{u}_j \varepsilon dn_j = \int \frac{\mu_t}{\sigma_\varepsilon} \frac{\partial \varepsilon}{\partial x_j} dn_j + \int \left(C_{\varepsilon 1} P_k - C_{\varepsilon 2} \rho \varepsilon \right) \frac{\varepsilon}{\mathrm{k}} \mathrm{d}V$$

$$\int \frac{\partial \bar{\rho} \tilde{h}}{\partial t} \mathrm{d}V + \int \bar{\rho} \tilde{u}_j \tilde{h} dn_j = \int \left(\bar{q}_j - \overline{\rho u_j'' h''} \right) dn_j - \int \frac{\partial \bar{q}_i^r}{\partial x_i} \mathrm{d}V$$

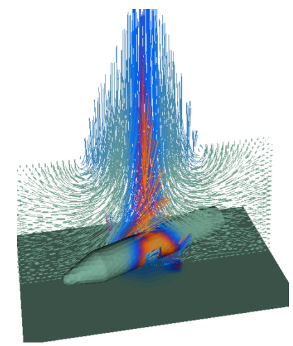
$$\int \frac{\partial \bar{\rho} \tilde{Y}_i}{\partial t} \mathrm{d}V + \int \bar{\rho} \tilde{u}_j \tilde{Y}_i dn_j = \int \left(\bar{\mathrm{j}}_{i,j} - \overline{\rho u_j'' Y_i''} \right) dn_j + \int \bar{\dot{\omega}}_{\mathrm{g}} \mathrm{d}V$$

$$s_i \frac{\partial \bar{I}}{\partial x_i} + \overline{\alpha I} = \frac{\overline{\alpha \sigma T^4}}{\pi}$$

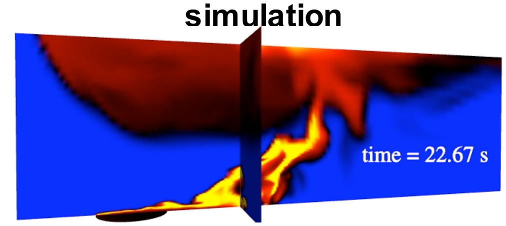
Radiative Transport Equation using DO (Lathrop and Carlson, LW, EM, SQS)



PMR natural convection simulation



5 m JP-8 pool fire simulation

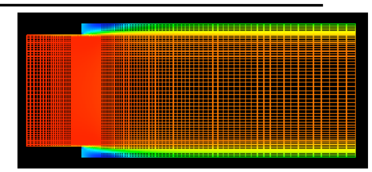


Fuego/Syrinx/Calore, XTF simulation

First Generation
Fluid Mechanics Closure Models

	Momentum	Species	Energy
Advection	$\overline{\rho u_i'' u_j''} = \mu_t \left(\frac{\partial \tilde{u}_i}{\partial x_j} + \frac{\partial \tilde{u}_j}{\partial x_i} \right) - \frac{2}{3} \bar{\rho} k$	$-\overline{\rho u_j'' Y_i''} = -\frac{\mu_t}{Sc_t} \left(\frac{\partial \tilde{Y}_i}{\partial x_j} \right)$	$-\overline{\rho u_i'' h''} = -\frac{\mu_t}{\mathrm{Pr}_t} \left(\frac{\partial \tilde{h}}{\partial x_j} \right)$
Production	$\rho = \frac{P_{th} MW}{RT}$	$\dot{\omega}_g \Leftarrow \mathrm{EDC/lam}$	$\frac{\partial q_i^r}{\partial x_i} \Leftarrow$ Syrinx

Standard k-ε $\mu_t = \rho C_\mu \frac{k^2}{\varepsilon}$ $P_k = \mu_t \left(\frac{\partial \tilde{u}_i}{\partial x_j} + \frac{\partial \tilde{u}_j}{\partial x_i} \right) \frac{\partial \tilde{u}_i}{\partial x_j} - \frac{2}{3} \bar{\rho} k \frac{\partial \bar{u}_n}{\partial x_n}$


Backward facing step, k-e

v2-f (Durbin) $\mu_t = \rho C_\mu v^2 T$

BVG modified k-ε $\mu_t = \rho C_\mu \frac{k^2}{\varepsilon}$ $P_k = \mu_t \left[\left(\frac{\partial \tilde{u}_i}{\partial x_j} + \frac{\partial \tilde{u}_j}{\partial x_i} \right) \frac{\partial \tilde{u}_i}{\partial x_j} + 0.35 \frac{\| \nabla \rho \times \nabla P \|}{\rho^2} \right] - \frac{2}{3} \bar{\rho} k \frac{\partial \bar{u}_n}{\partial x_n}$

Temporally Filtered k-ε $\mu_t = \rho C_\mu k \min(\frac{k}{\varepsilon}, \tau_{filter})$ $P_k = \mu_t \left(\frac{\partial \tilde{u}_i}{\partial x_j} + \frac{\partial \tilde{u}_j}{\partial x_i} \right) \frac{\partial \tilde{u}_i}{\partial x_j} - \frac{2}{3} \bar{\rho} k \frac{\partial \bar{u}_n}{\partial x_n}$

k-sgs, PANS, low Reynolds k-ε

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A Family of Approximate Projection Methods

- **Define a family of schemes using three projection time scale parameters, τ_1, τ_2, and τ_3:**

$$\begin{bmatrix} \mathbf{A} & \mathbf{G} \\ \mathbf{D} & \mathbf{0} \end{bmatrix} \begin{Bmatrix} \mathbf{U}^{n+1} \\ \mathbf{P}^{n+1} \end{Bmatrix} = \begin{Bmatrix} \mathbf{f} \\ \mathbf{0} \end{Bmatrix}$$

$$\begin{bmatrix} \mathbf{A} & \mathbf{0} \\ \mathbf{D} & -\mathbf{L}_1 \end{bmatrix} \begin{Bmatrix} \hat{\mathbf{U}} \\ \hat{\mathbf{P}} \end{Bmatrix} = \begin{Bmatrix} \mathbf{f}\left(\mathbf{U}^n\right) - \mathbf{G}\mathbf{P}^n \\ -\mathbf{L}_1\mathbf{P}^n + \left(\mathbf{L}_2 - \mathbf{D}\boldsymbol{\tau}_2\mathbf{G}\right)\mathbf{P}^n \end{Bmatrix}$$

$$\begin{bmatrix} \mathbf{I} & \boldsymbol{\tau}_3\mathbf{G} \\ \mathbf{0} & \mathbf{I} \end{bmatrix} \begin{Bmatrix} \mathbf{U}^{n+1} \\ \mathbf{P}^{n+1} \end{Bmatrix} = \begin{Bmatrix} \hat{\mathbf{U}} \\ \hat{\mathbf{P}} \end{Bmatrix} + \begin{Bmatrix} \boldsymbol{\tau}_3\mathbf{G}\mathbf{P}^n \\ \mathbf{0} \end{Bmatrix}$$

$\tau_1 \rightarrow$ pressure solve
$\tau_2 \rightarrow$ pressure smoothing
$\tau_3 \rightarrow$ velocity update

with Laplacian operators given by

$$\mathbf{L}_1 \equiv \nabla\boldsymbol{\tau}_1\nabla$$
$$\mathbf{L}_2 \equiv \nabla\boldsymbol{\tau}_2\nabla$$
$$\mathbf{L}_2 \neq \mathbf{D}\boldsymbol{\tau}_2\mathbf{G}$$

For CVFEM:

$$\mathbf{G}_{IJ} = \int_{\Gamma_I} N_J \mathbf{n}\, dA$$
$$\mathbf{D}_{IJ} = \int_{\Gamma_I} N_J \mathbf{n}^T dA$$
$$\left[\mathbf{L}_1\right]_{IJ} = \int_{\Gamma_I} \tau_{1J} \nabla N_J \cdot \mathbf{n}\, dA$$

- **Pressure stabilization terms are related to τ_2**
- **Pressure solve and velocity projection related to τ_1 and τ_3**

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SIERRA/Fuego
Stabilized Approximate Projection Algorithm

Momentum/Continuity:

$$\begin{bmatrix} \mathbf{A} & \mathbf{0} \\ \mathbf{D} & -(\boldsymbol{\tau} + \Delta t\mathbf{I})\mathbf{L} \end{bmatrix} \begin{Bmatrix} \hat{\mathbf{U}} \\ \hat{\mathbf{P}} \end{Bmatrix} = \begin{Bmatrix} \mathbf{f} - \mathbf{G}\mathbf{P}^n \\ -(\Delta t\mathbf{L} + \mathbf{D}\boldsymbol{\tau}\mathbf{G})\mathbf{P}^n \end{Bmatrix}$$

Nodal Projection:

$$\begin{bmatrix} \mathbf{I} & \boldsymbol{\tau}\mathbf{G} \\ \mathbf{0} & \mathbf{I} \end{bmatrix} \begin{Bmatrix} \mathbf{U}^{n+1} \\ \mathbf{P}^{n+1} \end{Bmatrix} = \begin{Bmatrix} \hat{\mathbf{U}} \\ \hat{\mathbf{P}} \end{Bmatrix} + \begin{Bmatrix} \boldsymbol{\tau}\mathbf{G}\mathbf{P}^n \\ \mathbf{0} \end{Bmatrix}$$

Splitting Errors:

$$\begin{bmatrix} \mathbf{A} & \mathbf{G} \\ \mathbf{D} & \mathbf{0} \end{bmatrix} \begin{Bmatrix} \mathbf{U}^{n+1} \\ \mathbf{P}^{n+1} \end{Bmatrix} = \begin{Bmatrix} \mathbf{f} \\ \mathbf{0} \end{Bmatrix} + \begin{Bmatrix} (\mathbf{I} - \boldsymbol{\tau}\mathbf{A})\mathbf{G}(\mathbf{P}^{n+1} - \mathbf{P}^n) \\ \boldsymbol{\tau}(\mathbf{L} - \mathbf{D}\mathbf{G})\mathbf{P}^{n+1} + \Delta t\mathbf{L}(\mathbf{P}^{n+1} - \mathbf{P}^n) \end{Bmatrix}$$

$\tau_1 \rightarrow$ pressure solve
$\tau_2 \rightarrow$ pressure smoothing
$\tau_3 \rightarrow$ velocity update

- Parameter $\boldsymbol{\tau}_1$ is mix of characteristic and time step
- Parameters $\boldsymbol{\tau} = \boldsymbol{\tau}_2 = \boldsymbol{\tau}_3 = \boldsymbol{\tau}_{char}$
- Examples:
  - Soto *et al.* (2001) derived from monolithic scheme of Codina (2001)
- Remarks:
  - No CFL stability limit
  - Continuity error proportional to $\boldsymbol{\tau}$ and 4th derivative of pressure
  - No steady-state dependence on time step
  - Blend of terms to enhance both time stability and pressure smoothing
  - Can show sporadic convergence; works better with large Δt

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Review of Presentations to Come

- Code Documentation
- Code SQE
- Code Verification

SIERRA/Fuego/Syrinx Documentation

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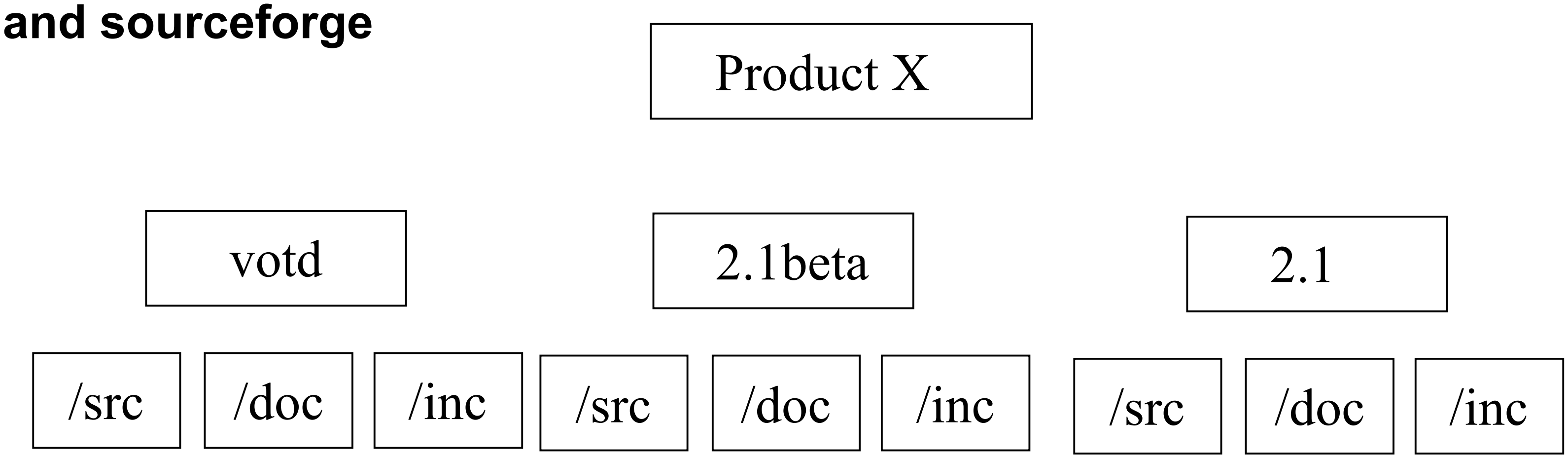
Presentation Outline

- Overview of Documentation Provided by the SIERRA/Fuego/Syrinx Team
  - Theoretical Manual
  - Verification Manual
  - User Manual
  - Training Materials
  - Technical Papers and Presentations
  - Release Notes
- Overview of Documentation related to “run time”
  - SNTools Distribution Status
  - SNTools “how to” per Code per Platform
- SIERRA/Fuego Over Arching Principle:
  - We do not expect the code base to be the primary means of communication of features and implementation!

SIERRA/Fuego and SIERRA/Syrinx Version Control

• SIERRA/Fuego and SIERRA/Syrinx version control is managed via CVS and sourceforge



• Each code is maintained as a separate product, however, the SIERRA/Fuego executable contains SIERRA/Syrinx

• A branch occurs when the SIERRA/Fuego and SIERRA/Syrinx product, which includes all supporting artifacts, are tagged

• At distribution, all associated documentation is specific to the version number

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SIERRA/Fuego and SIERRA/Syrinx Theory Manual

- A set of technical document of approximately 300 pages that contains:
  - Numerical methodology
  - Math model descriptions
  - Code implementation and design aspects
- The theory documents are modified as required as new models are supported
- As already described, the manual resides under the code specified product version and is distributed along with the product
- The manual represents a joint effort between the application and development groups

SIERRA/Fuego
Theory Manual Example

- **Formal equation documentation, e.g., section 2.6 "Turbulent Flow Equations; Favre Averaged"**

2.6.2 Conservation of Momentum

$$\int \frac{\partial \bar{\rho}\tilde{u}_i}{\partial t} \mathrm{d}V + \int \bar{\rho}\tilde{u}_i\tilde{u}_j n_j \mathrm{d}S + \int \bar{p} n_i \mathrm{d}S = \int \overline{\tau_{ij}} n_j \mathrm{d}S - \int \overline{\rho u_i'' u_j''} n_j \mathrm{d}S + \int (\bar{\rho} - \rho_\circ) g_i \mathrm{d}V \quad (2.57)$$

2.6.3 Conservation of Energy

$$\int \frac{\partial \bar{\rho}\tilde{h}}{\partial t} \mathrm{d}V + \int \bar{\rho}\tilde{h}\tilde{u}_j n_j \mathrm{d}S = -\int \overline{q_j} n_j \mathrm{d}S - \int \overline{\rho h'' u_j''} n_j \mathrm{d}S - \int \frac{\partial \overline{q_i^r}}{\partial x_i} \mathrm{d}V \quad (2.58)$$

The simple Fickian diffusion velocity approximation, Equation 2.35, is assumed, so that the mean diffusive heat flux is

$$\overline{q_j} = -\overline{\left[\frac{\mu}{\Pr}\frac{\partial h}{\partial x_j} - \frac{\mu}{\Pr}\sum_{k=1}^{K} h_k \frac{\partial Y_k}{\partial x_j}\right]} - \overline{\frac{\mu}{\mathrm{Sc}}\sum_{k=1}^{K} h_k \frac{\partial Y_k}{\partial x_j}}. \quad (2.59)$$

If Sc = Pr, (Le = 1), the resulting energy equation is given in Libby and Williams [12], p. 25, as

$$\int \frac{\partial \bar{\rho}\tilde{h}}{\partial t} \mathrm{d}V + \int \bar{\rho}\tilde{h}\tilde{u}_j n_j \mathrm{d}S = \int \overline{\frac{\kappa}{C_p}\frac{\partial h}{\partial x_j}} n_j \mathrm{d}S - \int \overline{\rho h'' u_j''} n_j \mathrm{d}S - \int \frac{\partial \overline{q_i^r}}{\partial x_i} \mathrm{d}V. \quad (2.60)$$

2.6.4 Conservation of Species

The form of diffusion velocities (see Equation 2.35) assumes the Fickian approximation with a constant value of diffusion velocity for consistency with the turbulent form of the energy equation, Equation 2.58.

$$\int \frac{\partial \bar{\rho}\tilde{Y}_k}{\partial t} \mathrm{d}V + \int \bar{\rho}\tilde{Y}_k\tilde{u}_j n_j \mathrm{d}S = -\int \overline{\rho Y_k'' u_j''} n_j \mathrm{d}S + \int \overline{\rho Y_k \hat{u}_{j,k}} n_j \mathrm{d}S + \int \overline{\dot{\omega}_k} \mathrm{d}V. \quad (2.61)$$

SIERRA/Fuego/Syirinx User's Manual

- A technical document of approximately 400 pages that contains:
  - Brief subset of theory manual, numerics, and implementation
  - Code specific line commands with summary and descriptions
    - prsr_handlers are tied to XML via unique triplet, i.e, (usage, type, unique number); SNTool::command_summary() queries code base, specifically, prsr_register_commands(), and "extracts" line commands (can be filtered)
    - Fuego user manual Makefile, via LaTex, converts extracted XML database to a "user friendly" manual in ps and navigatable pdf
    - As part of SIERRA/Fuego/Syrinx SQE "software engineering process", developers are expected to add summaries and descriptions of new line commands
    - User manual can be generated easily prior to code check-in thereby providing up-to-date line commands even for votd code!

SIERRA/Fuego/Syrinx User's Manual Example

• **Line Command, Determine Utau [wall friction velocity] via Nonlinear Law of the Wall**

```
DETERMINE UTAU VIA NONLINEAR LAW OF THE WALL ITERATION
```

Type	Line
Scope	FUEGO REGION

Summary

Use law of the wall nonlinear iteration for utau calculation

Description

Elect to perform a nonlinear iteration of the law-of-the-wall formula to calculate utau, the wall friction velocity at the boundary integration points. This value will be used to calcualte the wall shear stress when using the standard k-e wall function model. Alternatively, the friction velocity will be calculated from the nodal value of turbulent k.e.

SIERRA/Fuego/Syrinx Verification Manual

- Two independent technical documents of approximately 250 pages that contains model descriptions and results for all verification problems run to date
- Details of the input file are provided in the text
- Verification problems are each binded to SIERRA/Fuego/Syrinx SQE regression testing via a special "verification" keyword

SIERRA/Fuego Verification Manual Example

- **Chapter 17, Surface Transfer Verification**

Chapter 17: Surface Transfer Verification

Dimension:	3D
Transient/Steady:	steady
Laminar/Turbulent:	laminar
Isothermal/Thermal:	thermal
Temperature/Enthalpy:	temperature
Uniform/Nonuniform:	uniform
Combustion:	no
Soot:	no
Coupled Mechanics:	no
Regression Test:	fuego/tetHexFluidCond

This problem is used to verify the implementation for surface transfers used for fluid/solid (laminar and turbulent) and solid/pmr fire mechanics transfers.

The first problem represents testing of a heterogeneous surface transfer (quad:triangle) for the laminar heat transfer boundary condition. The fluid region is a hex topology while the conduction region is a tetrahedral topology. The fluid domain has boundary conditions that result in a quiescent flow with a wall temperature of 10. The conduction region has a temperature specification of 0. Each of the regions share the same conduction coefficient, thereby allowing a perfectly linear temperature profile.

SIERRA/Fuego/Syrinx Training Material

- Goal: Creation of a SIERRA/Fuego/Syrinx "short-course"
  - Draw from theory manual to provide a condensed set of presentations that can be presented in a two-day tutorial
- Material is to include technical presentations for:
  - Discretization techniques, low Mach number approximation, projection algorithms, turbulence models, combustion model, etc.
- These set of presentations are placed under cvs under the SIERRA/Fuego product, e.g.,
  - home/sntools/Src/Sierra/fuego/votd/doc/trainingMaterial/FuegoTraining_lowMachBasics.ppt
- Each of the above set of presentations exists and only need a common "look and feel" in addition to version control

SIERRA/Fuego/Syrinx
Technical Papers and Presentations

- **Technical papers and presentations are, again, placed under version control under /doc that lives under the SIERRA/Fuego product**
  - **2002 IMECE, 2003 ASME, 2003 CFD, 2005 MIT, etc.**
- **Some presentations, most often monthly team meeting notes, are also placed under sourceforge.sandia.gov**

Approximate projection methods and time integration stability

C.D. Moen*[a], S.P. Domino[b], G.J. Wagner[a]

[a] *Sandia National Laboratories, Livermore, CA 94550, USA*
[b] *Sandia National Laboratories, Albuquerque, NM 87185, USA*

SIERRA/Fuego/Syrinx Release Notes

- Release notes, in simple text format, are maintained under the scico.sandia.gov/fuego website
- Notes include:
  - new features
  - syntax changes, etc.

SNTools Product Distribution Status

- Users want to know the status - to the minute - of code distributions
- Color coded to indicate the state of any particular stable version

Product	Version Name	Version Number	Unclassified								
			Linux Desktops *updated: 2005-11-08*	Rogue *updated: 2005-11-08*	AIX/sais028 *updated: 2005-11-08*	ICC/Liberty *updated: 2005-11-08*	ICC/Shasta *updated: 2005-11-08*	IRIX/sasg1099 *updated: 2005-11-08*	NWCC/Spirit *updated: 2005-11-08*	sun7/sass2889 *updated: 2005-11-08*	sun7/sass3276a *updated: 2005-11-08*
Fuego	2.0beta	2.0.10									
Fuego	2.1beta	2.1.0									
Fuego	2.1beta	2.1.6									
Fuego	2.2beta	2.2.0									
Fuego	2.2beta	2.2.2									

SNTools Documentation
How to …

- User's need to know where and how to run code
- Paths, commands, etc., are provided

SNTools

This document can be customized to fit your environment. To do so please select from the following

Platform: Generic

Shell: Generic

Code: Generic

How To Run SIERRA Applications

Contents: 1. Document Overview

1. Document Overview

This document provides a guideline on how to run SIERRA applications on various platforms.

Supported Platforms

This section provides information about the platforms that support SIERRA applications:

- Brief description of machines and nodes
- Logging in to a machine
- Parallel Communication Protocol (IP, GM)
- Helpful Links and e-mail addresses

Setting Up Your Environment

SNTools Documentation
One Location

- User's and developers expect one location for this information

SNTools

Sierra Information

- How To Run Sierra Applications
- The Sierra Tool

A Brief Introduction To The Tools

- Nightly Regression Test Web Interface
- Sierra Distribution Status Pages
- Usage Statistics Prototype Page
- Result percentages
- Summary of regression test results
- An Introduction to the SNTools for Sierra Developers
- A glossary of terminology used when discussing the tools.
- A brief introduction to navigating the source for an SNTool.
- The following are links to all available SNTools Man pages.:

System	Tools
Sierra	checkin.html

Testimonial

- James Sutherland, 1541 post doctoral staff member; new developer and user
- Documentation, rtests, support, etc., allowed for:
  - Running the code within an afternoon
  - Core development within a month, i.e., formal check-in

October 27, 2005

To Whom It May Concern:

I began using and developing Fuego in September 2004. The Fuego/Syrinx user manual has proved very useful in learning how to run the code. Of particular use are the command line summaries that were added in the past year, which provide details regarding input syntax.

As a developer, the Fuego/Syrinx theory manual has been an invaluable asset. The CVFEM formulation employed in Fuego is not in widespread use through the CFD community. Thus, quality documentation is very important. The theory manual provides a good description of the CVFEM method, together with detailed descriptions of each equation and model employed in Fuego. The discussions of discretization (in space and time) are also helpful in understanding the algorithms employed in Fuego.

Sincerely,

____
James Sutherland

Conclusions

- The SIERRA/Fuego/Syrinx team is committed to detailed documentation
- The documentation cited in this presentation assists the end-user to be more productive by providing:
    - Theoretical details of models
    - Numerical implementations
    - User manuals that outline the details of line commands
    - Code's verification state
    - Research aspects of the project, to understand implemented models, numerics
- Equally valued documentation, which has been developed by the SNTools team, includes answers to the following questions:
    - "where and how can I run SIERRA/Fuego/Syrinx?
    - "what version of SIERRA/Fuego/Syrinx is available on Renegade?

Towards Code Adequacy

- SIERRA/Fuego/Syrinx established documentation adequacy

☑

- SIERRA/Fuego/Syrinx established SQE adequacy

☐

- SIERRA/Fuego/Syrinx established verification adequacy

☐