Long Title of This Talk

With A Subtitle If Necessary

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Your 10-15 minute presentation will have . . .

- 2 slides on intro to the problem
- what feature you're adding if appropriate
- build system and version control infos
- Verification plan
- Convergence plots
- Grvy timer results or something similar
- Code coverage (if appropriate)
- How did you start out?
  - What worked?
  - What didn't work?
- If you were starting over . . .
  - What would you do differently?
  - What would you do the same?
- Lessons learned

Simple ODE

- forward euler has been implemented in the c++ code
- we solve a simple first order ODE, i.e. $y' = y$
-
-

Example 1: 2 Blocks with nested item lists

First Block

- First Item
  - Subitem
- Second Item:
  - More subitems
  - And more

Second Block

- With an item

Example 2: 2 Columns;
one column with two blocks, one block with two columns!

Block 1

- item 1
- item 2
- item 3
- item 4
- item 5
- item 6

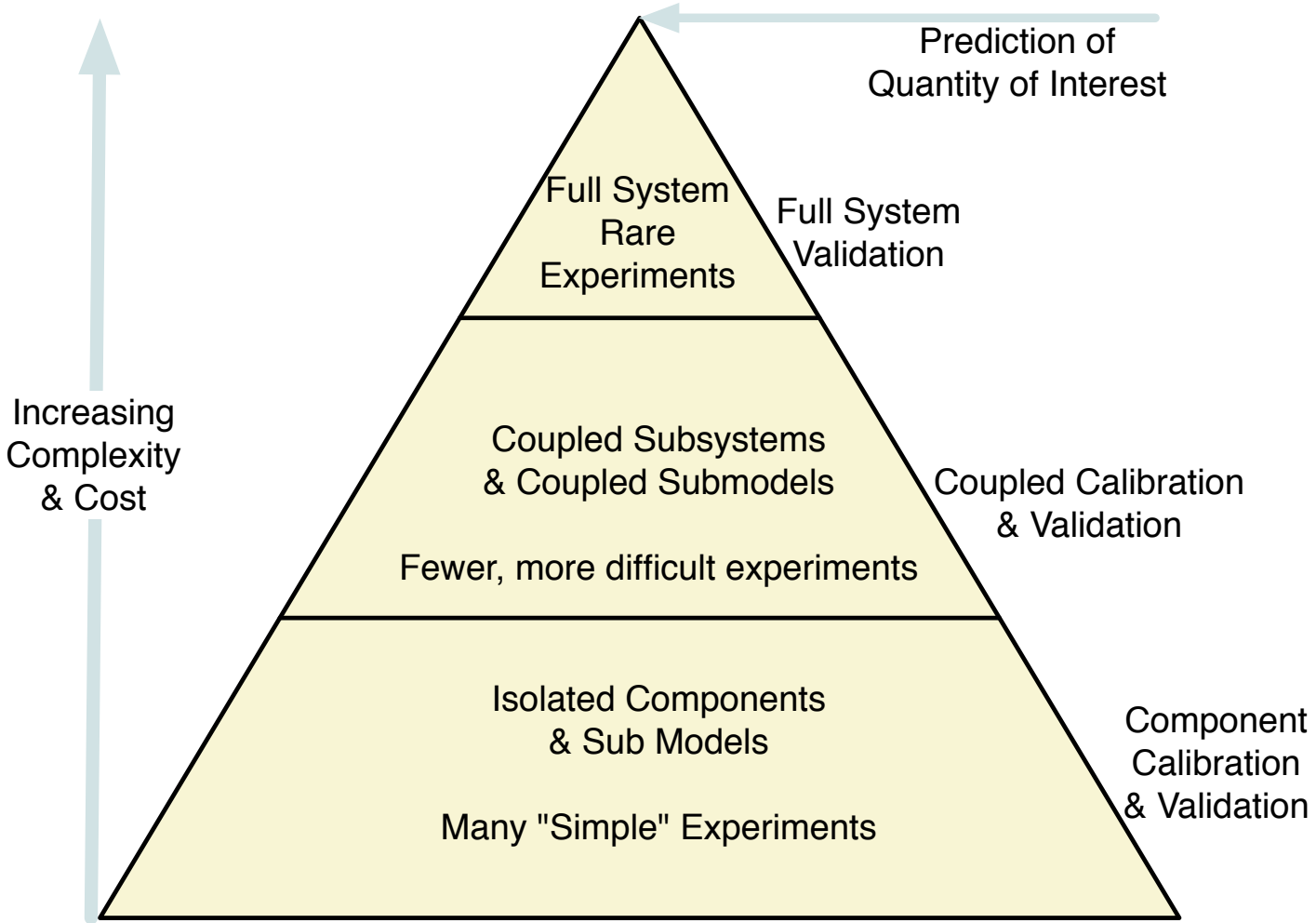
Block 2

- item A
- item B

Block 3

- item a
- item b
- item c
- item d

Image and Bullet points



- Validation is done repeatedly with increasingly complex scenarios
- Validation pyramid may be recursive

Two Blocks with added text for emphasis

V&V-UQ framework *requires* experimental data

Calibration of component model parameters

- Thermochemistry (e.g. kinetic parameters)
- Radiation (e.g. absorptions & emissions)
- Turbulence (e.g. model constants)
- Ablation (e.g. kinetic parameters)

Validation

- Component and subcomponent models
- Coupling between models
- Full system

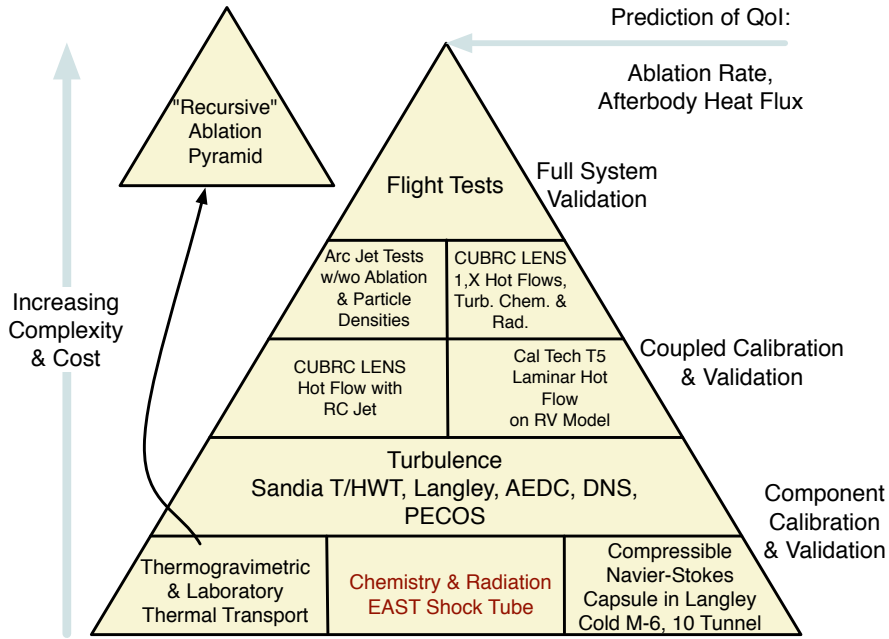
1 Block and 1 Image in Column format

Extensive experimental data

- Space Act Agreement
  - Ames EAST
  - Langley RCS
  - Ames & JSC Arc Jets
  - AEDC T9
  - CUBRC
  - Cal Tech
- Legacy data
- Sandia
- PECOS

Facility	Description	Flow	Measure	Calibration	Validate
UT	TGA	N/A	Mass(T) slow heat	Ablation Kinetics	Ablation
EAST	Shock Tube	Hypersonic	Radiometry	Chemistry, Radiation	Aerothermo, radiation
Langley	RV model	M=6,10,cold, laminar	q_s,T_s		Navier-Stokes
Langley RCS	RCS model	M=10,cold, laminar	q_S,P_s		Navier-Stokes
Sandia HWT	Sphere-cone model	M=5,8,14, cold	P_s,ρ_u	Turbulence	Turbulence
Sandia TWT	Turbulent BL w/steady cross-flow	M=0.8,cold	$u(2-D)$	Turbulence	Turbulence
Sandia TWT	Turbulent boundary layer	$M < 3$, cold	P_s, $u(2-D)$	Turbulence	Turbulence
Langley	Legacy Boundary layer experiments	$M < 11$, cold	ρ_u, T	Turbulence	Turbulence
AEDC T9	RV model w/wo roughness	M=6,cold	q_s, T_s	Turbulence	Turbulence, transition
ArcJet	PICA and copper targets	$M < 12$, hot,long	Particle density	Particles	Part. gen/ transport
ArcJet	Ablative material flow	$M < 12$, hot,long	q_s, T_s, σ_s, Recession		All
CUBRC LENS 1	Model w/ blowing / roughness	$M < 25$, hot	P_s, q_s, T_s, σ_s		All except ablation
CUBRC LENS	Model w/ RCS jets	$M < 25$, hot	P_s, q_s, T_s, σ_s		All except ablation
CUBRC LENS X	RV Model	$M < 25$, hot	P_s, q_s, T_s, σ_s		Turbulence, chemistry, radiation
CalTech T5	RV Model	$M < 5$, hot,laminar	q_s, T_s		Chemistry, radiation, transport
Fire II	Apollo-era flight test		q_s, T_s, Radiometry		All
Apollo IV	Apollo lunar exchange flight test		q_s, T_s, Radiometry		All
LEO	CEV Low exchange orbit		q_s, T_s, Radiometry		All
LEX	2m capsule lunar exchange		q_s, T_s, Radiometry		All
Stardust	Comet sample-return mission		TPS condition		All

1 image and 1 itemized Block

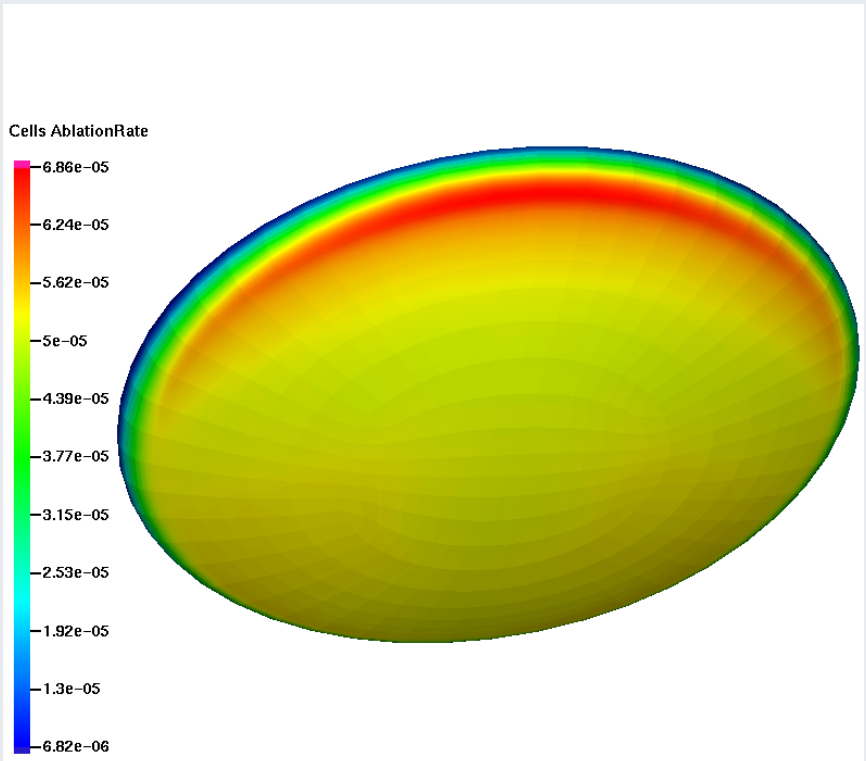


Goals

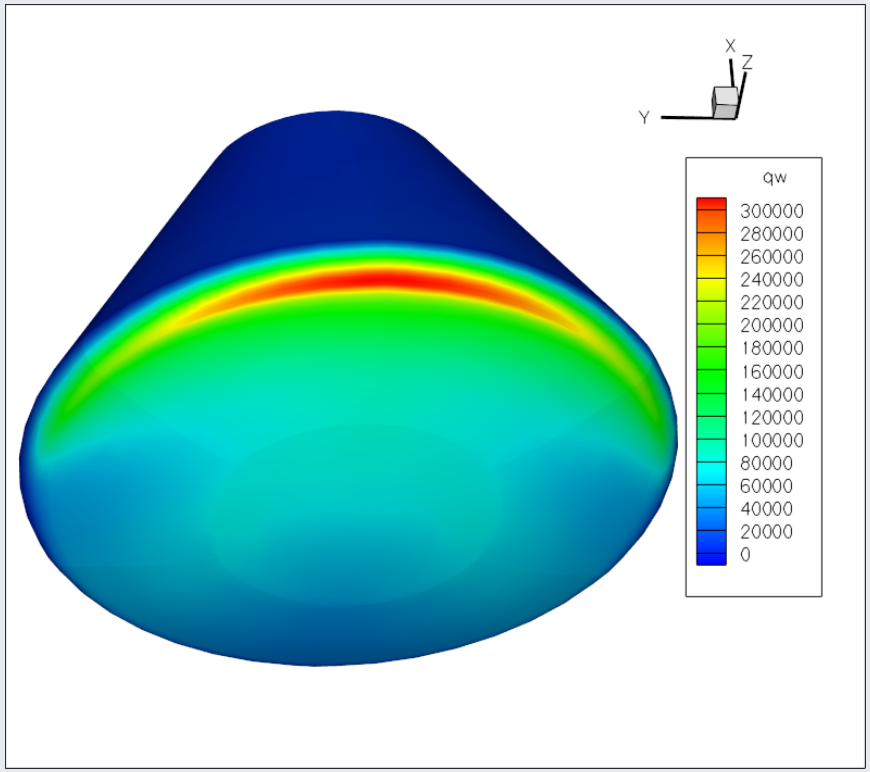
- Calibrate and (in)validate a two-temperature thermochemical model
- Investigate implementation of the validation cycle with QUESO
- Develop a 1D problem for future exploration of adjoints

Two Images in Two Blocks in a Column

Surface Ablation Rate



Surface Heat Flux



Fancy Block / Column work

Goals

- Demonstrate capability to couple ablation and radiation models with existing hypersonic code (DPLR)
- Evaluate sensitivity of the ablation rate and peak heat flux (QoIs)
  - Identify most important models
  - Evaluate utility of surrogate quantities of interest

Coupled hypersonic flow for LEO and lunar reentry, including:

- Arrhenius chemistry
- Gray temperature dependent radiation
- Algebraic(Baldwin-Lomax) turbulence models
- Thermal nonequilibrium
- Single phase flow (i.e. no particles)
- 1-dimensional solid-phase ablation with ad hoc kinetics (as in CMA, FIAT, Chaleur)
- Equilibrium surface chemistry

Thank you!

Questions?