# ADVANCED CHARACTERIZATION OF PARTICULATE FLOWS FOR CONCENTRATING SOLAR POWER APPLICATIONS

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TOPIC AREA 2B: GEN3 RESEARCH AND ANALYSIS
CONTROL NUMBER: 1697-1525

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CSP KICKOFF MEETING

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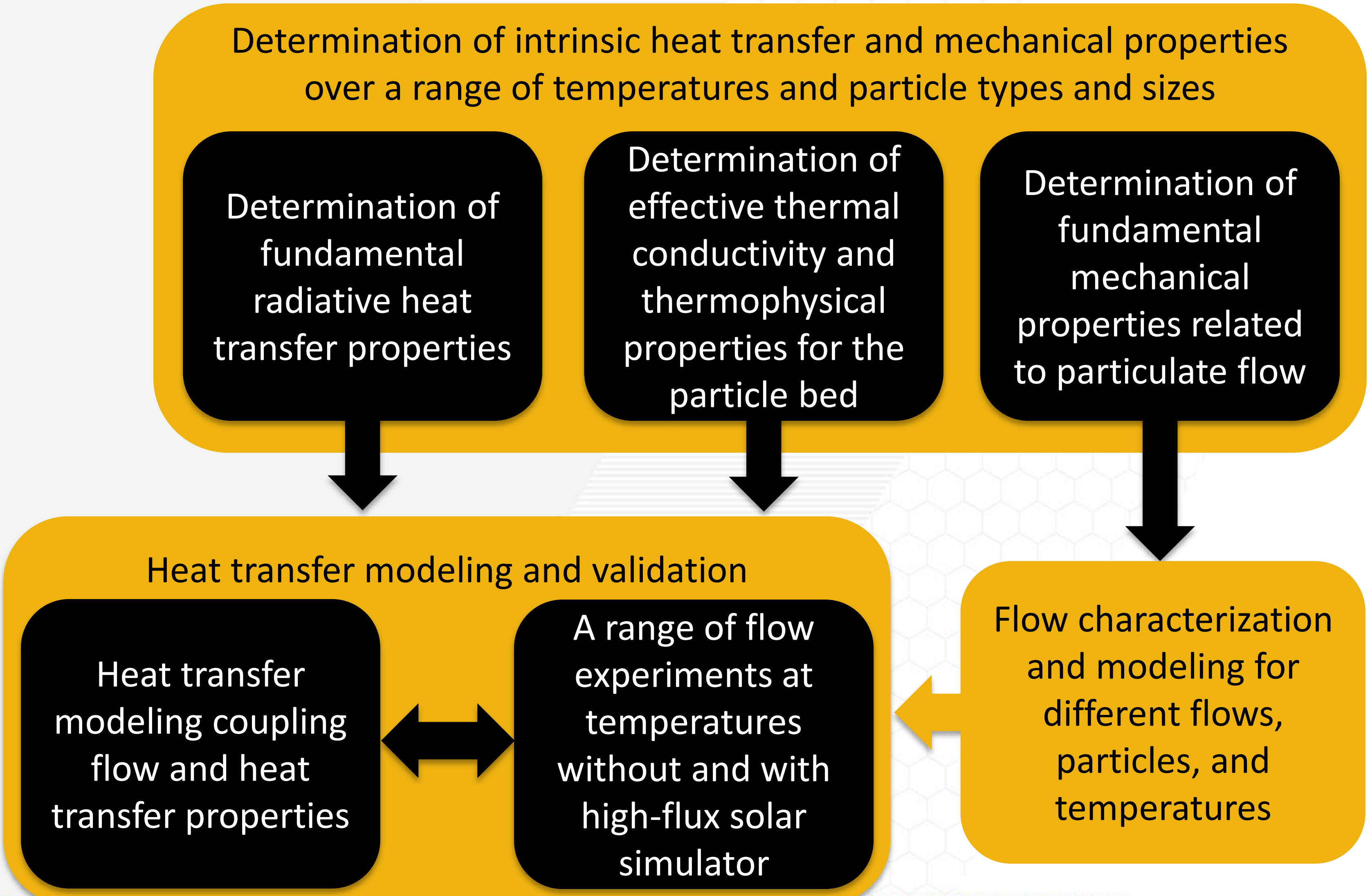
CREATING THE NEXT®


Determination of intrinsic heat transfer and mechanical properties over a range of temperatures and particle types and sizes
Determination of fundamental radiative heat transfer properties
Determination of effective thermal conductivity and thermophysical properties for the particle bed
Determination of fundamental mechanical properties related to particulate flow
Heat transfer modeling and validation
Heat transfer modeling coupling flow and heat transfer properties
A range of flow experiments at temperatures without and with high-flux solar simulator
Flow characterization and modeling for different flows, particles, and temperatures

# TEAM AND ADVISORY BOARD

Georgia Tech

PIV Analysis & Flow Modeling

CSP

Heat and Mass Transfer Modelers

Radiative Heat Transfer



## Advisory Board


Dr. Cliff Ho


Prof. Hany Al-Ansary


Prof. Sheldon Jeter

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# PROJECT OUTCOMES

Georgia Tech

Accessible database/publications containing “first of their kind” results related to particulate flows as tools to catalyze next generation solar particle heat receivers/reactors:

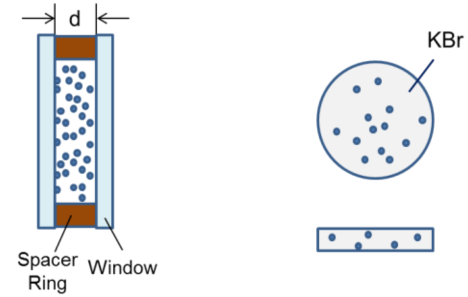
- Intrinsic heat transfer and flow properties for particulate flows for a range of particles
- Particulate flow experiments and models
- Simple to complex experiments for a range of particles, temperatures, and flow configurations
- Validated heat and mass transfer models

# INTRINSIC PROPERTIES: RADIATIVE HEAT TRANSFER

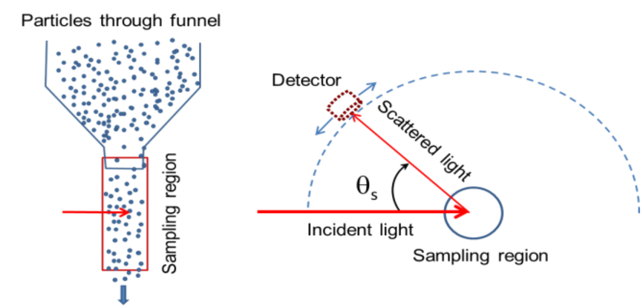
Examine radiative heat transport through a range of packed beds between 25 – 800 °C and 0.35 to 16 µm and using a range of modeling techniques (*e.g.*, Monte Carlo ray-tracing)

- Measure the spectral emissivity from the sample
- Measure scattering and determine the scattering phase functions
- Develop a method to characterize the boundary conditions

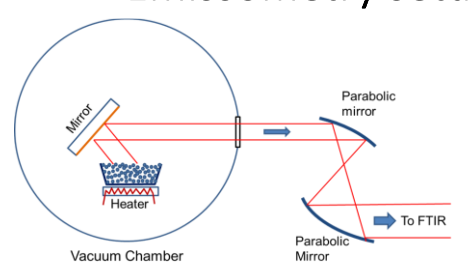
## Sample Preparation




## Laser light scattering measurement setup




## Emissometry setup



# INTRINSIC PROPERTIES: THERMOPHYSICAL AND MECHANICAL

Specific heat, density, etc. would be measured in-house via heat lab user facility

Preliminary effective thermal conductivity correlations that have been validated flow characterizations up to 1300 °C

Effective thermal conductivity measurements:

- Prof. Shannon Yee's Gen3 proposal to fabricate an inline immersion electrothermal instrument

Georgia Tech's user facility: Mechanical Properties and Characterization Facility

- Young's modulus
- Poisson's ratio
- Dynamic coefficient of friction, etc.

# FLOW CHARACTERIZATION

Georgia Tech

## Tilt flow rig modifications

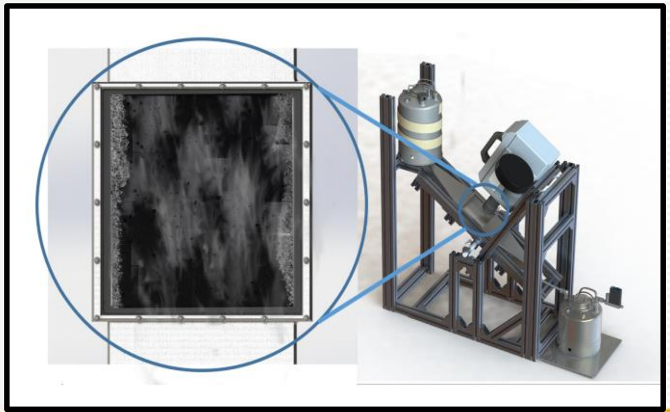
- Tube furnace to heat particles
- Window to control environment
- Near-IR camera to measure spatial temperature
- Addition of impediments and upward flows to assess a range of flow configurations

## Measurements

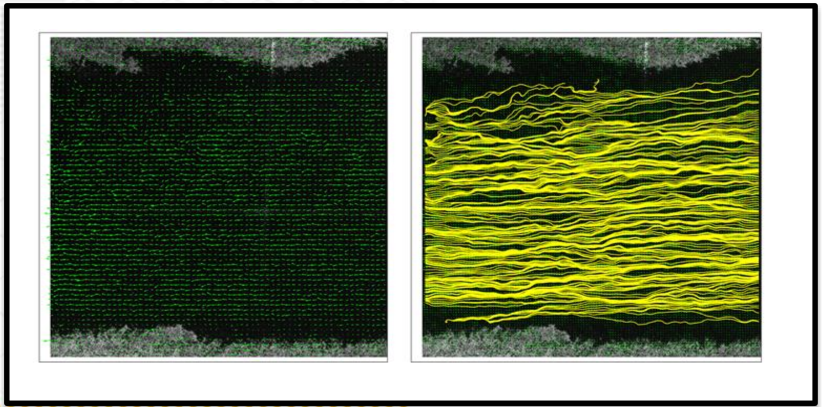
- Surface temperature (to assess heat transfer models)
- Surface velocity profiles and mass flow rate
- Validations for flow and heat transfer modelling

## Modeling: Flow modeling with LIGGGHTS (a discrete element method particle simulation software)

Schematic of tilt flow right



Velocity field measurement



# HEAT TRANSFER MODELING AND VALIDATION

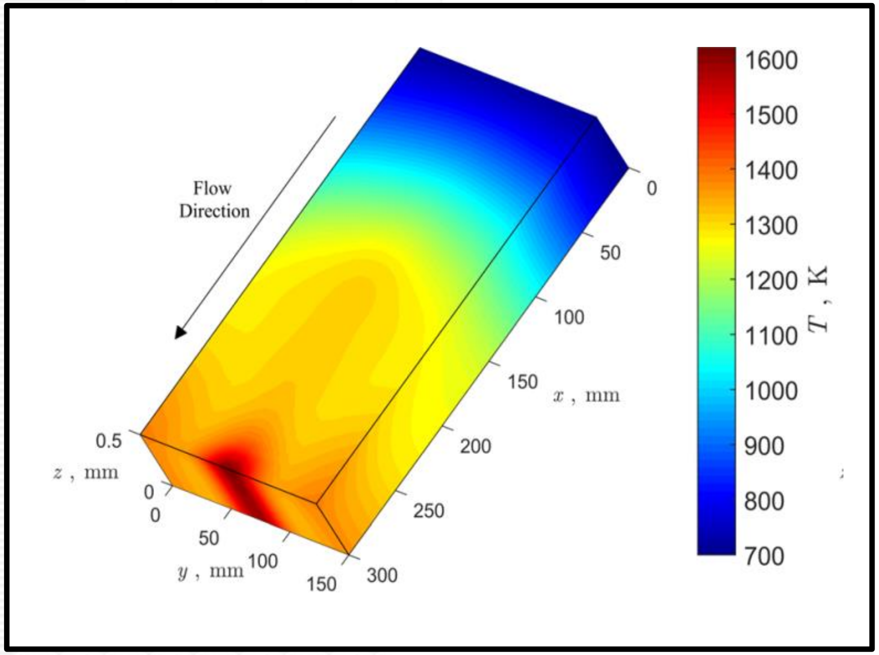
Heat and mass transfer modeling with a commercial code using inputs from

- Radiative heat transfer characterization
- Thermochemical properties and effective thermal conductivity

Validation

- Tilt flow rig experiments using spatial temperature and velocity measurements and mass flow

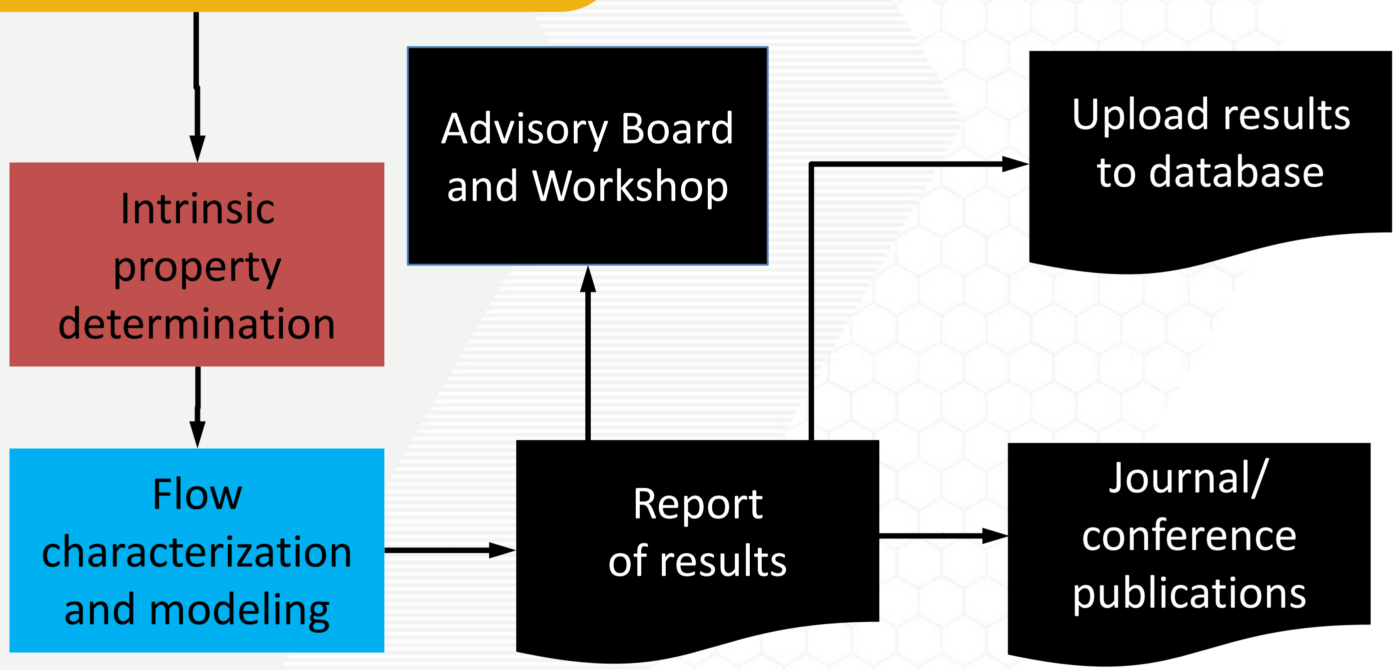
Previous modeling results



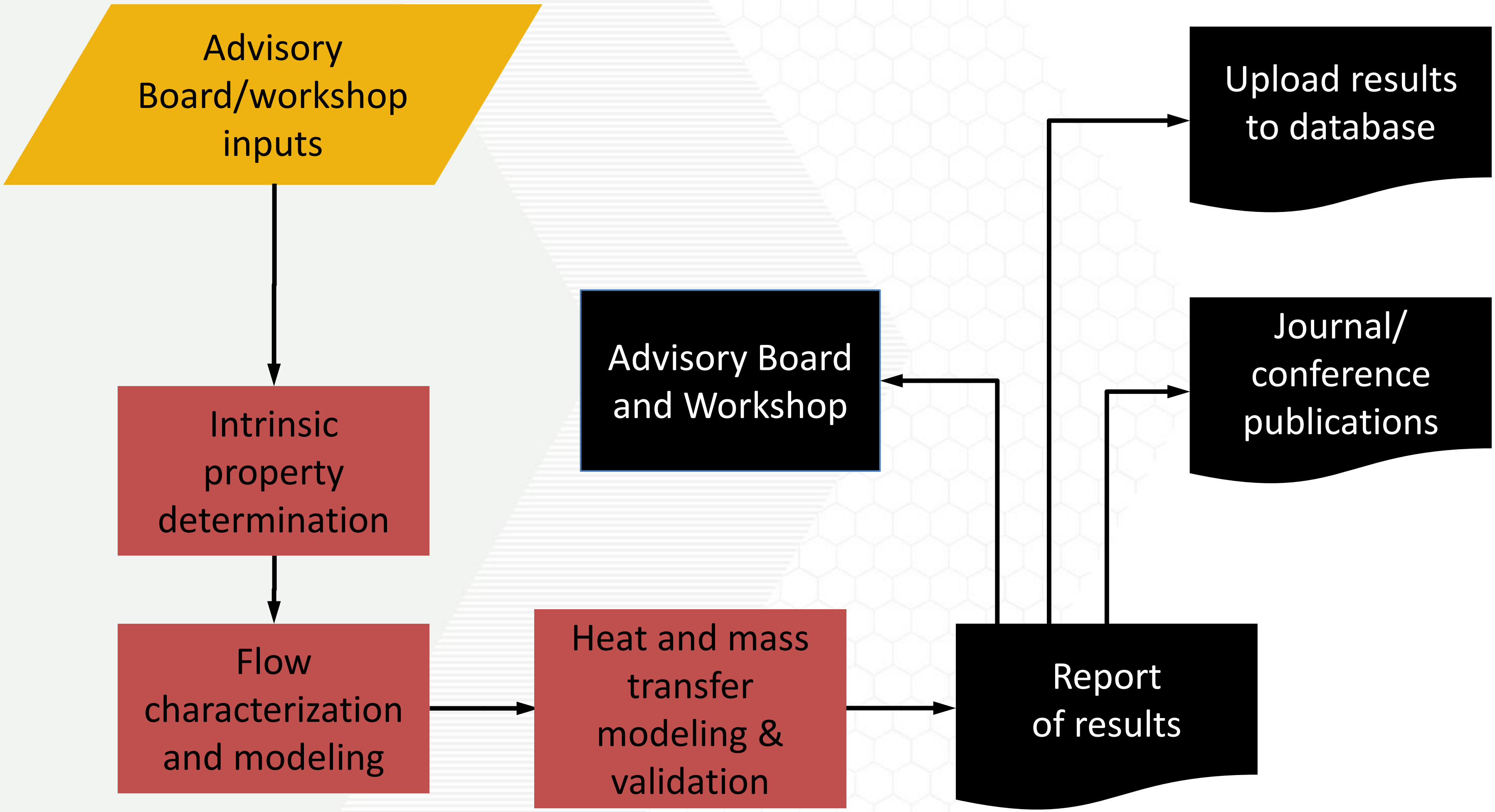
# PROJECT FLOW: YEAR 1

## Baseline materials (Sintered Bauxite)

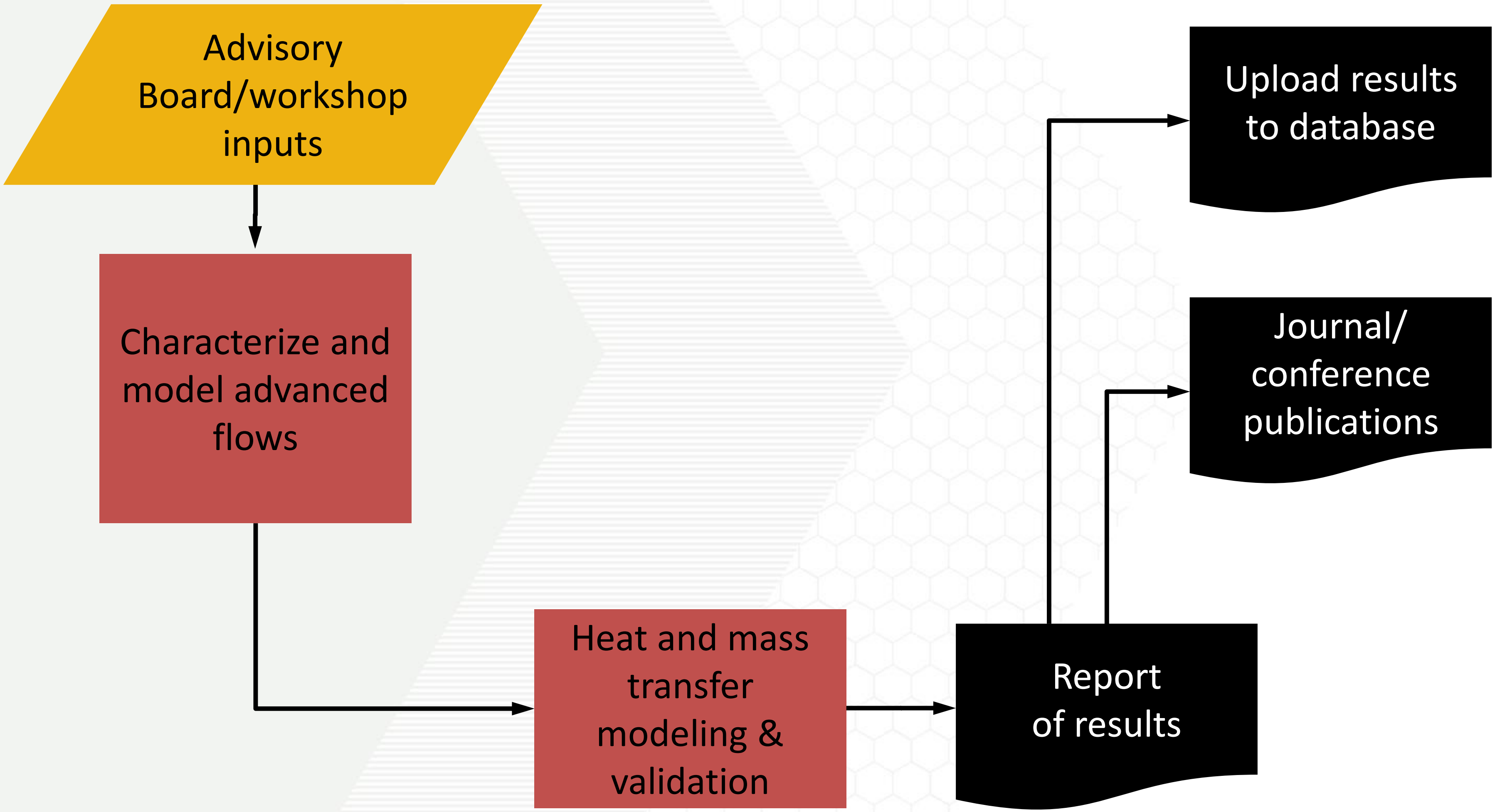
| Material Name | Type |
|---|---|
| Carbo HSP | Sintered Bauxite |
| CarboProp 40/70 | Sintered Bauxite |
| CarboProp 30/60 | Sintered Bauxite |
| Accucast ID50K | Sinter Bauxite |
| Accucast ID70K | Sintered Bauxite |
| Fracking Sand | Silica |



# PROJECT FLOW: YEAR 2



# PROJECT FLOW: YEAR 3



## SUMMARY AND CONCLUSIONS

- We have proposed to extend the state-of-the-art for particulate flows related to CSP
- The proposed work addresses a **significant** gap related to particulate flows at elevated temperatures
- Our team combines expertise from CSP, fundamental radiative heat transfer, flow characterization to create important synergies for successful completion of project objectives