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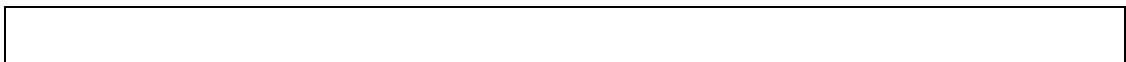
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**(Simulated Based Design)**

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**(Build & Test)**

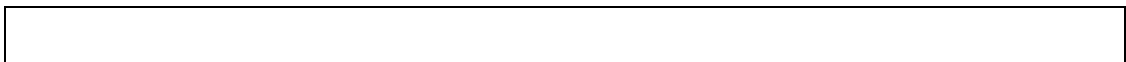
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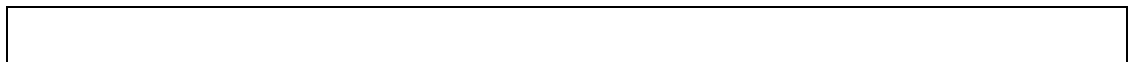
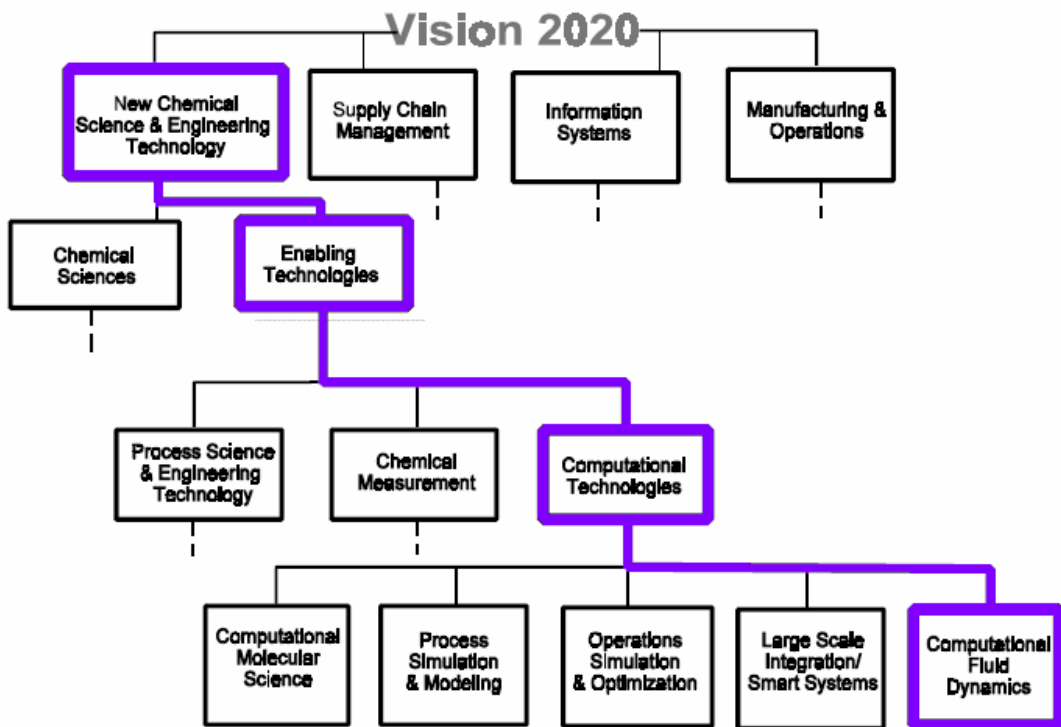
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Numerical Methods	Phenomenology and Constitutive Relations	Experimental Validation
<p>Characterize/model dilute to dense phases ✦</p> <p>Develop relevant data sets for code verification and scaling ✦</p> <p>Incorporate complex geometry ●</p> <p>Develop adaptive computational grids ●</p> <p>Design modules to customize complexity for different user needs ●</p> <p>Improve parallelization techniques ●</p> <p>Develop more efficient, accurate algorithms and solvers ●</p> <p>Characterize/model chemistry and chemical coupling phenomenon for multi-phases ○</p> <p>Develop algorithms to treat the changing position of a free surface (e.g., molten polymers) ○</p> <p>Develop wrap-around optimization using large-scale CFD simulation and small parameter models ○</p>	<p>Characterize/model dilute to dense regimes (e.g., laminar/turbulent flows) ✦</p> <p>Characterize/model interactions between phases ✦</p> <p>Develop reliable turbulence closures for multi-phase flows ✦</p> <p>Characterize boundary conditions and interactions (e.g., inlets and wall and interior surface interactions) ✦</p> <p>Develop chemistry models for volume and surface phenomenon ●</p> <p>Characterize/model polydisperse systems ○</p> <p>Incorporate population balance ○</p> <p>Characterize/model multiphase heat transfer ○</p>	<p>Design/develop multiphase flow test beds ✦</p> <p>Perform experimental validation at small scale ✦</p> <p>Conduct small and large scale separate effects tests ✦</p> <p>Develop new diagnostics and sensors for experimental measurement of multi-phase flows ✦</p> <ul style="list-style-type: none"> <li>- Non-invasive</li> <li>- Full-field, rather than local or averaged</li> <li>- Increase spatial and temporal resolution</li> </ul> <p>Enhance capability for analysis of results ●</p> <p>Develop new experimental methods applicable to large scale flows ●</p>
<p>Key: ✦ = Top Priority ● = High Priority ○ = Medium Priority</p>		

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