

# Cheryl Teich

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### Intro: RAPID DEPLOY Process Technology Scale Up

We have designed the conference as a teaching and learning event to kickstart a specific RAPID 2.0 deliverable:

"Develop a methodology for determining the scale-up readiness of a technology and its supporting components."

Federal Agency/	DOE/EERE/
<b>Organization Element:</b>	Industrial Efficiency and Decarbonization Office (IEDO)
FOA Name and	DE-FOA-0001578/ Modular Chemical Process Intensification
Number:	Institute for Clean Energy Manufacturing (Renewal)
Award Number:	DE-EE0011122



# Before we start, a round of applause for the producers

Frank van Lier Interim RAPID® Executive Director



Justin Canna Manager, Program Development AIChE





Keith Joseph Director of Education and Workforce Development RAPID ®





Sally Kremer Engineering Associate Program Development AIChE



### Let's Start with Some Operational Definitions

### Develop a **methodology** for determining the

### scale-up readiness of a technology and its

supporting components.



# What do we mean

by "scale-up"\*?



He who knows not, and knows not that he knows not

"Kinjal made a batch in the lab, so, we plan on going commercial in two months."

Unidentified Marketing Manager, Rohm and Haas Personal Care Business, ca. 2012 He who knows not, and knows that he knows not

"Scaling up is hard."

Professor Moungi Bawendi 2023 Nobel Laureate in Chemistry MIT Club of the Delaware Valley Presentation March 19, 2024. He who knows and knows that he knows

"The goal is commercial success."

"The Yoga of Process Development" Kamlesh Bhatia DuPont (ret.) 2008 AIChE Annual Meeting, Paper 373g



\*Yogi's choice: scale-up, scaleup, scale up



# What do we mean by "components"?

- Define the "System": include anything requiring development
- Raw materials must be commercially available at a scale consistent with manufacturing
  - Key players
  - Catalysts
  - Crosslinkers
  - Inhibitors
- Equipment and peripherals must be compatible with manufacturing operation
  - Electrical classification
  - Reactive chemicals
  - Material of construction
- Equipment test sites and units must be safe







This is NOT a catalyst manufacturing process!



Custom manufacturing of a low volume ingredient cannot drive the cost

crylic monom

Acrylic monomer swells PTFE









## What do we mean by "methodology"?

https://www.merriam-webster.com/dictionary/methodology

A body of methods, rules, and postulates employed by a discipline: a particular procedure or set of procedures



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"Process Development is analogous to Yoga. It is a 'Yoga' – a disciplined process for integrating the essential components to create a vision of the 'Whole' and experiencing the 'Joy' of professional satisfaction."

The Yoga of Process Development" Kamlesh Bhatia DuPont (ret.) 2008 AIChE Annual Meeting, Paper 373g







### Methodology ≠ Assessment Scale

NASA Developed the Technology Readiness Level Scale (TRLs) to Assess "Mission-readiness"

https://www.nasa.gov/directorates/somd/space-communicationsnavigation-program/technology-readiness-levels/





# Many government agencies have adapted the NASA scale to their applications



Technology Readiness Assessment Guide DOE G 413.3-4A Approved 9-15-2011 Chg 1 (Admin Chg) 10-22-2015



# DOE has charged RAPID with developing a methodology to move the TRL = ~ 3 to 9



Technology Readiness Assessment Guide DOE G 413.3-4A Approved 9-15-2011 Chg 1 (Admin Chg) 10-22-2015

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### My favorite methodology: Process Development Workflow



NIST Funded RAPID RACER AMPD under the American Rescue Act (Financial Assistance Award 70NANB22H006)



#### **Process Development: It never gets old!**



\*Aaron Sarafinas, Rohm and Haas Company, "Successful Process Development: Profitable Specialty Chemical Products Using Winning Work Processes, AIChE Process Development Symposium, June 2003

#### Process Development Workflow Aligns with Defined Deliverables and Milestones





### Developing a process scheme answers the call to "Know Your Process".

Gas, [Solvent] Phases Draw a picture Components Bulk Liquid (Solvent) Rates Imposed T profile Feed A(g) A(g) + B(s) > P(s)k<sub>l</sub>a Solubility В Ρ Solid Solid

Headspace



Process Understanding leads to the best process/technology match

### The Process Scheme Shows the Key Info

- 4 Phases: gas, liquid, 2 solids
- 4 Components: A, B, P, Solvent
- 2 Rates: reaction and gas-liquid mass transfer





### Can a HAZOP-like **methodology** determine if a technology is ready for prime-time?





### Each of our process stars provides a unique view of scale-up – as do you



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# Your Assignment: listen

### ask lots of questions!



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My Job:

- Facilitate the discussion
- Take copious notes
- Synthesis an overall methodology from the "parts"



# Thank you for spending your weekend with us at RAPID DEPLOY!

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