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Finding Balance between Science, Engineering and Technology

TECHNOLOGY DRIVES EXPLORATION

#321TechOff

For Human Exploration, All Roads Lead to Mars



- **NASA's vision:**
 - To reach for new heights and reveal the unknown so that what we do and learn will benefit all humankind
- **Why is Mars the new height?**
 - It is the only destination if humanity is to leave the cradle of Earth
- **How do we get to Mars?**
 - Through balance between science, technology, commercial, international and human endeavors



Balance between Science, Engineering & Technology



- Each plays a vital yet distinct role
 - Technology develops the new engineering tools,
 - That enable the engineers to build more capable missions,
 - That answer the increasingly challenging and fundamental questions of science

Science

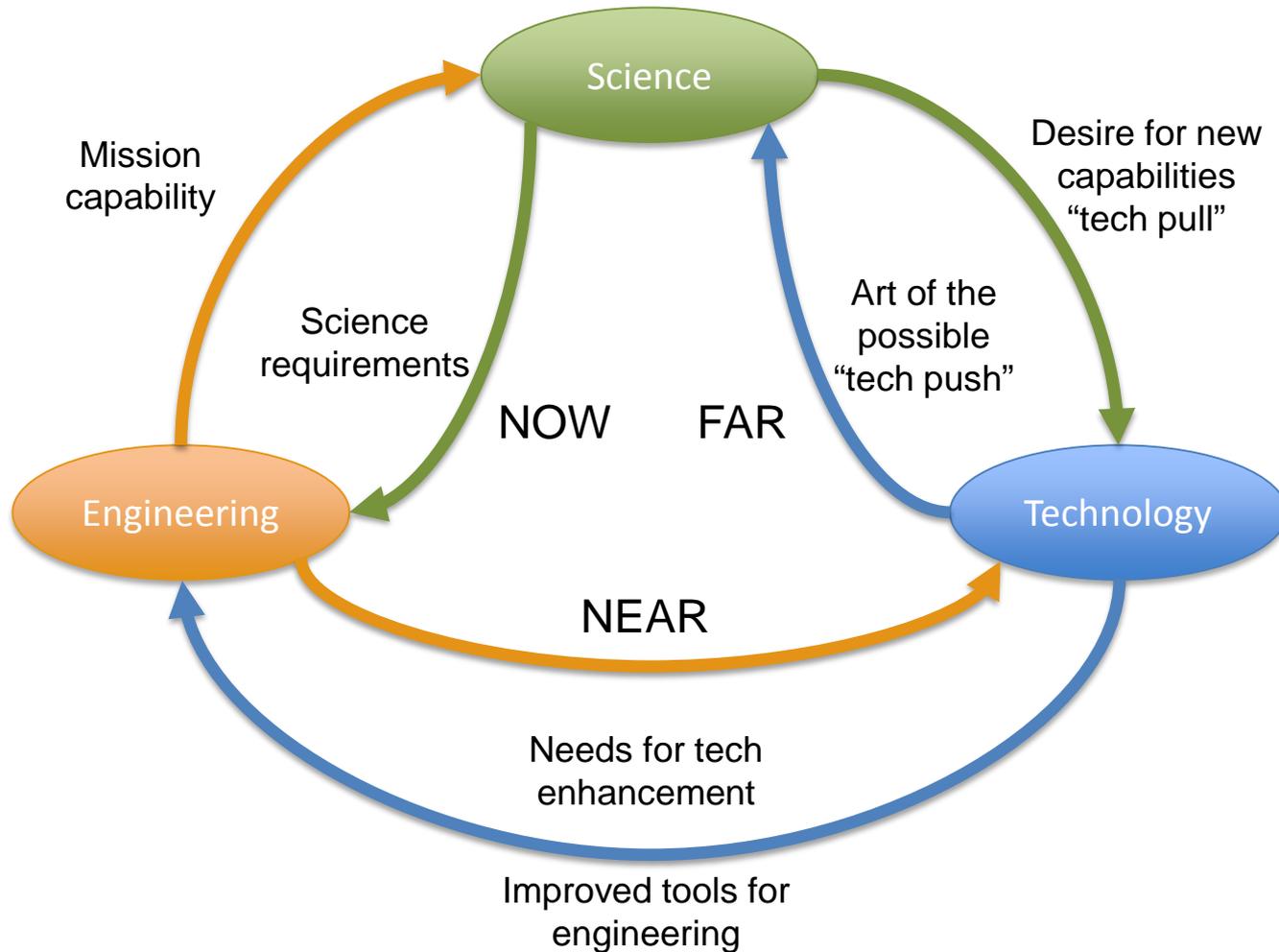
- All three dialogues are essential
 - Science and Engineering to best satisfy mission requirements
 - Engineering and Technology to improve driving SWaP, cost and risk elements
 - Technology and Science to identify game changers

Engineering

Technology

***These three dialogues are essential in advancing exploration,
as well as technical know-how***

The Dialogue between Science, Engineering & Technology



All three dialogues must exist to ensure that we can build the missions of today and realize the vision of tomorrow

The Balance between Analysis and Test



- **Analysis and simulation help us understand the “what ifs”**

- But only if we trust them
- They are doomed to succeed
- They only contain the physics we chose to include
- They need to be verified
 - Did we build the models right?
- They need to be validated
 - Did we build the right models?
- Over the range of our “what ifs”

- **Test provides the validation of our analysis and simulation**

- But only if traceable to the authentic environment
- Used to identify both parametric and non-parametric uncertainties (insufficiencies)
- Can be expensive and therefore limited and conservative
- Cannot exhaustively span the “what ifs”
- Leads to a culture of “paralysis by analysis” and “cannot fail”
- But we learn more by testing to failure

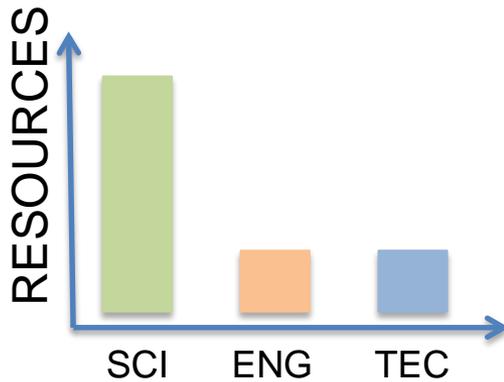
The only tests that fail are those from which we do not learn

In the advancement of technology, we should be ready and willing to break anything once

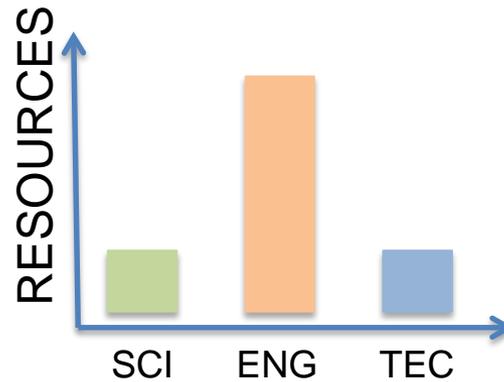


- **We need to balance as well as stabilize the investment between basic and applied technology research**
 - To be less prescriptive about needed technology improvements
 - Also focus on needed science capabilities
 - Permit new technical solutions to emerge from the bottom up
 - So that we have the key fundamental understanding needed to move from applied research to robust operational insertion
 - It's not a serial process from basic to applied to operation
 - Often the systems integration process reveals that we do not fully understand some fundamental behaviors
 - Augment theory with experiment at all stages of development
 - Test is the analog equivalent to the digital simulation
 - The cost of test actually saves total resources when done correctly

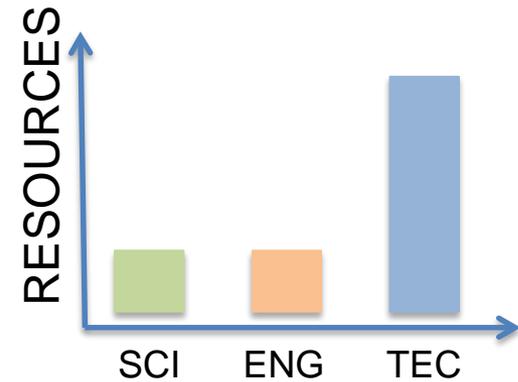
Achieving a Balanced Portfolio



- Engineering and technology are insufficient to support
 - Capabilities do not improve
 - Costs overrun
 - Schedules stretch
 - Missions are cancelled



- Science has insufficient need and technology does not innovate
 - Facilities and expertise are unused
 - Maintenance and labor costs dominate
 - Morale drops



- Science has insufficient need and engineering customer disappears
 - Developed without a goal
 - Limited opportunity to mature
 - Becomes a sandbox

Finding the proper balance is essential

Strike that Balance!



- **Whether you are a scientist, engineer, technologist, program manager, financial officer, etc, you need to walk a mile in each others' shoes in order to**
 - Understand their perspective, motivation, and constraints
 - Learn to speak their language so that you impedance match your efforts
 - Become a team so that you can resolve disagreements efficiently and effectively
 - Hold these dialogues and do not suppress ideas from left field
- **When laying out how your team is going to develop your program, be sure to**
 - Think through risk (technical, financial, schedule, human resource, etc.) and articulate how that motivates your development strategy
 - Always revisit this risk assessment process and be ready to adapt your development process
 - Be able to identify when a given line of inquiry is delivering diminishing returns and be ready to adapt your process
 - Always ask yourself what it is that you still don't know and figure out how to learn it



Questions?

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