Welcome!

NSF-NASA Extreme Design & Wicked Problems Workshop

Workshop Organizers & Facilitators

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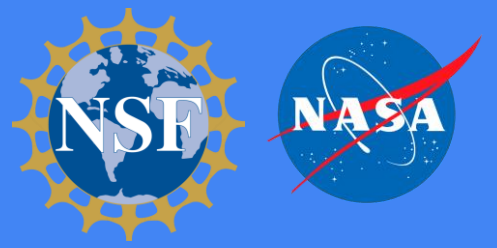
Agenda

Time: 2:10 – 5:50 pm
Break: 3:50 pm – 4:10 pm

- Welcome and Introductions
- Motivation
- NSF and NASA Programs
- Examples / Attributes of Extreme Design and Wicked Problems
- Group Work
- Pair Work
- Feedback
- Closing / Final Q&A

Motivation: Why are *we* here?



- To learn how we might solve some important and challenging problems that require us to step into extreme or “wicked problem” domains …
- Where systems-level engineering and design are required to integrate with other domains
- Connect with the external community to cross-pollinate on best methods, processes, and tools

Motivation: Why are *you* here?

10 mins

NSF EDSE Program:

Engineering Design and Systems Engineering

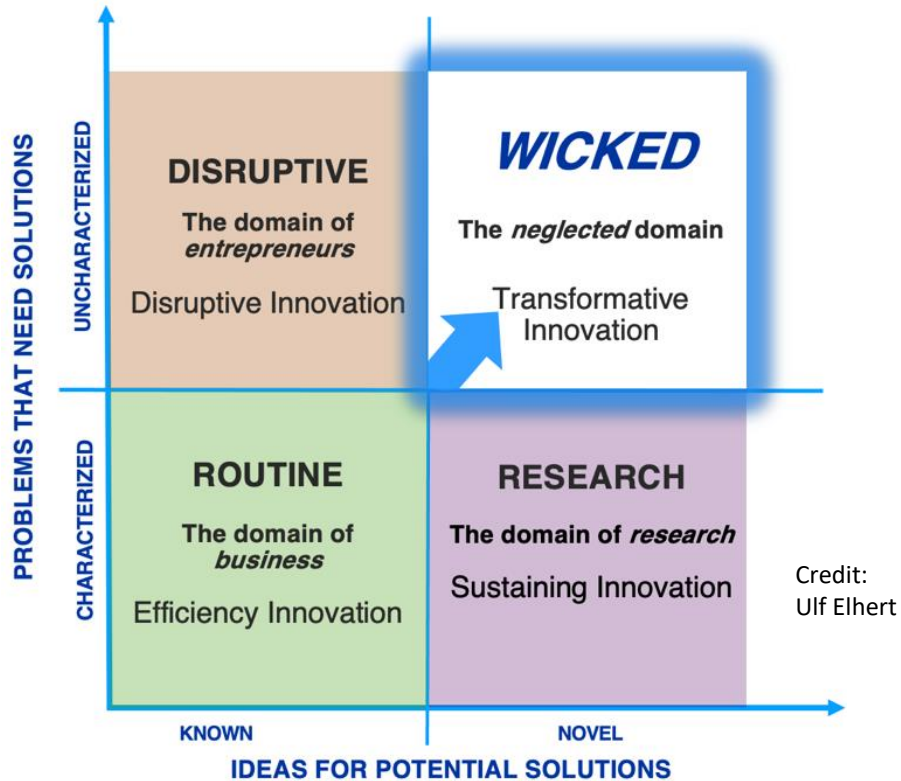
With Interest in **Extreme Design**

- Extreme scales
- Extreme environments
- Extreme physical qualities
- Extreme constraints
- Extreme risks
- “Impossible things”

NASA Aeronautics Project:

Convergent Aeronautics Solutions (CAS)

With Interest in **Wicked Problems**



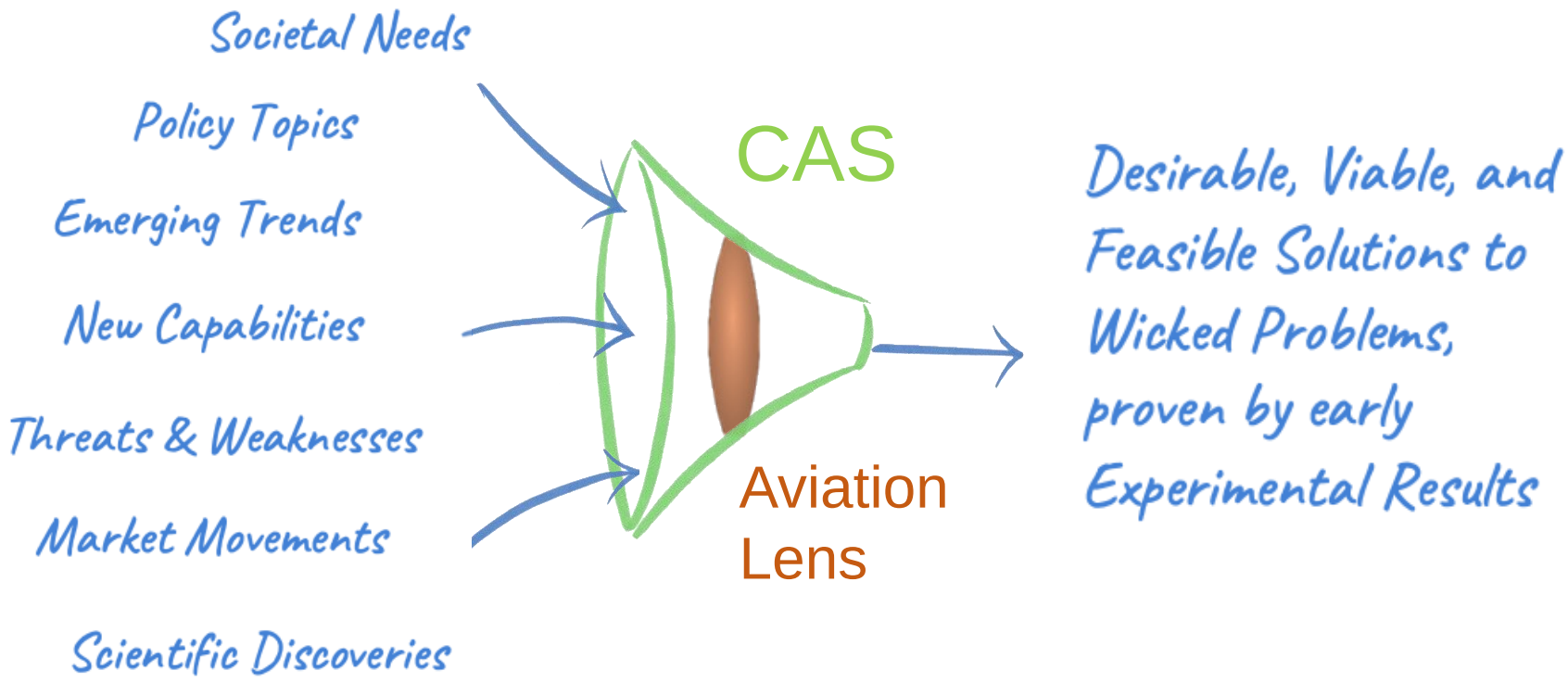
Credit: Ulf Elhert

Engineering Design and Systems Engineering (EDSE) Program

- EDSE supports fundamental research that advances ***design science*** **and/or** ***systems science*** through the creation of new knowledge about the **design of engineered artifacts.**
- ***Engineered artifacts*** include, but are not limited to, **devices**, **products**, **processes**, **platforms**, **materials**, **organizations**, **systems**, and **systems of systems**.
- **Focus:** The EDSE program focuses on ***design as a system***, in which **designers**, the **artifacts** they create, the **methods** they use to create them, and the **environment** in which this occurs are all subject to rigorous scientific inquiry, along with the **interactions** among these elements.

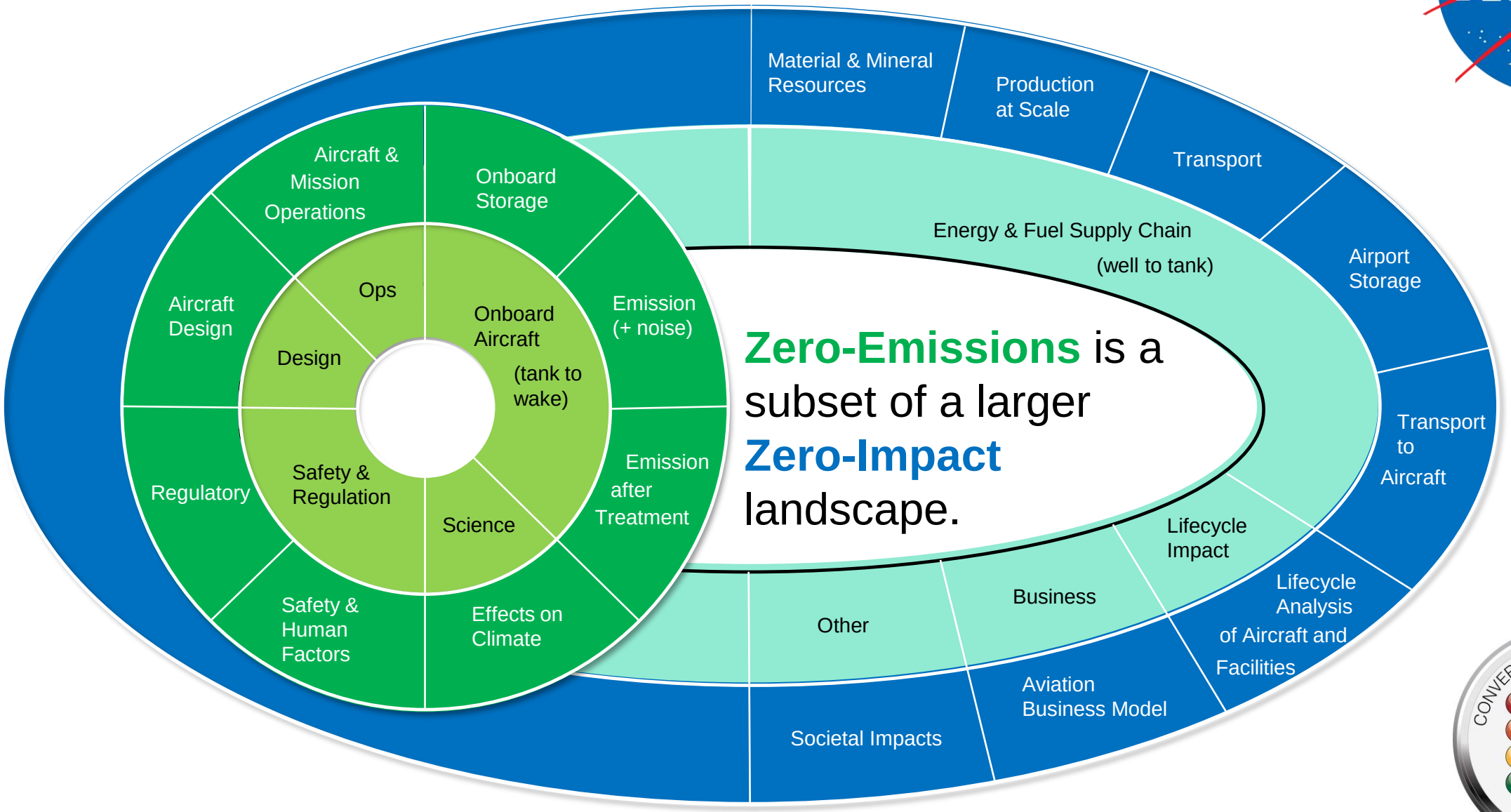
CAS Thinks Differently To Revolutionize Air Transportation

Explores the unknown - Converges disciplines & industries - Advances disruptive concepts



- ***Imagine*** desirable aviation futures
- ***Explore*** the most difficult, problems of aviation
- ***Discover*** pathways to overcoming barriers
- ***Test*** these pathways via vanguard experiments
- ***Incubate*** transformative change in aviation
- ***Emerge*** new strategic thrusts in ARMD

Scoping the Zero-Impact Aviation problem space



Extreme/Wicked Problem #1:

Revitalizing Rural Communities that Depend on One Industry

- To thrive and become resilient outside of single industry infrastructure
- Many regions in industrialized countries …
  - Remain isolated and lack access to goods, services, and resources that are vital to thriving
  - Often suffer from single-industry economic dependencies that limit growth opportunities and upward mobility, both individually and regionally

Extreme/Wicked Problem #2:
Democratizing Medical Supply Delivery

- Current medical supply transport is plagued by losses, including a relatively high temperature excursion rate.
- Delivery includes a diverse supply chain.
- Access to medical supplies is limited in some communities in the U.S. and abroad.
- Current U.S. regulatory and liability frameworks do not account for medical transport by non-traditional vehicles, such as drones.

Extreme Design and Wicked Problems

- *Span community, market, and national needs from individual human to global levels*
- *The path to impact may include considerations for: concept/system life-cycle; environmental and sustainability; economic and financial; regulatory and policy; supply chain; and infrastructure needs.*

Some Interrelated Attributes of Extreme Design & Wicked *Problems*

- **Multiple domains:** e.g., technical, economic, sociological, regulatory, etc.
- **Multiple people groups:** With diverse values and criteria for improvement, different understandings and differential impacts of the problem
- **Numerous irreducible interdependencies:** Making it impossible (currently) to effectively and comprehensively model/simulate, optimize, and test
- **Many explanations** of the origins/causes and root issues
- Each extreme/wicked problem can be considered **a symptom of another** problem; they are **progressively understood** as work is done

Some Interrelated Attributes of *Solutions* to Extreme Design & Wicked Problems

- Solutions can best be assessed in terms of **progress or improvements**, rather than optimization or completion, as there may be no right, wrong, or optimal.
- Implemented solutions may have **consequences that cannot be undone**.
- There's **no immediate or complete test** of a solution to extreme/wicked problems.
- The **“no stopping rule”**: Aspects of the problem persist even when solutions are effective at improvements (e.g., flu shots).

Group Work

Select an Extreme / Wicked Problem

Option 1

Revitalizing rural communities that depend on one industry

Option 2

Democratizing medical supply delivery

Approach For Each Theme

Step 1 (3 min): All group members read all questions for the theme.

Step 2 (12 mins): Group discussion around these questions or others that arise.

Step 3 (5 mins): 1-2 groups “one key headline” report out 

Each group member writes their top 2-3 takeaways on a notecard (these will be collected) – use as many cards as you wish.

Theme 1: Scope & Scale

1. **Scale:** How would you select the appropriate **scale(s)** at which to analyze the your extreme/wicked problem such that it captures the essential elements of the problem?

2. **Scope**: How would you **scope** the problem (i.e., tight enough to be tractable yet wide enough to not preclude solutions or leave out key stakeholders and problem elements)?

3. **Organizational Lens:** At what stage in your research would you **apply your disciplinary or organizational lens** to the problem framing (e.g., an aero/astro lens for NASA or a mechanical lens for a ME faculty member)?

Theme 2: Disciplines & Stakeholders

1. **Interdisciplinarity:** When, how, and to what extent would you integrate "the other" experts, disciplines, or knowledge groups into the problem and design research? Describe the nature of this integration (transactional, relational, mathematical, via models, papers, or presentations, and during team formation, problem framing, or ideation, etc.). Why this approach?

2. **Stakeholders:** When, how, and to what extent would you include stakeholders (e.g., affected community members, NGOs, etc.) as participants in the design process? Why this approach?

3. **Adaptations:** How might different categories of extreme/wicked problems call for different expert or stakeholder engagement/participation strategies?

Theme 3: Methods, Methodologies, & Data

1. **Useful Methods:** Which established design methods or methodologies would you use to address your extreme/wicked problem? Why? At what point in your design process would you use them? What are the boundaries of applicability of the methods (when to use them and when not to)?

2. **Limitations:** Which established design methods/methodologies would not work well for your extreme/wicked problem? Why?

3. **Data:** What data would you need throughout the design process? What data would you expect to be difficult to obtain? As some data must be gathered "in the field," how would you do so effectively and efficiently? What partners or support would you wish for in gathering/acquiring data?

Theme 4: Performance & ROI

1. **Evaluating:** How would you measure progress/quality/performance/impact in addressing your extreme/wicked problem? How would you integrate technical, economic, social, environmental, and other forms of performance?

2. **Diverging from established measures:** How would you consider creating any new Figures of Merit to assess the performance of your design process and/or solution? (e.g., Designing the laptop required valuing portability over metrics of importance for stationary computers.)

Theme 5: Paradoxes & Tensions

1. **Paradox of Structure**: At the start, you may need to keep your problem and solution spaces very large and ambiguous, yet you need *some* idea of where you are going to avoid getting completely lost.
   How would you navigate this paradox of structure?

2. **Paradox of Personnel**: The stakeholders and subject matter experts that you engage in the early design stages will affect the problem and solution spaces you explore. Yet these individuals may not be who is ultimately needed to address the problem.
   How would you manage an evolving set of personnel?

3. **Paradox of Commitment**: To establish trust and strong participation from a community or organization, you may need to make a commitment to them early in your design process. However, the situation could evolve in ways that no longer benefit that community or organization.
   How would you navigate this paradox of commitment?

4. **Tensions:** Every solution can create or aggravate another problem. How might you handle this?

Your Concepts

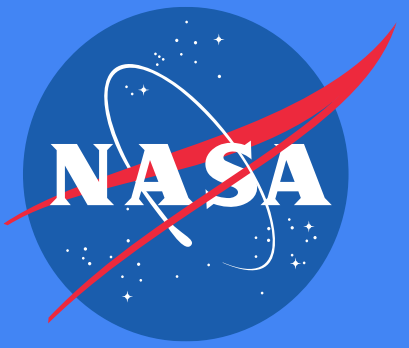
New Directions… In Pairs…

Help each other draft 1-pagers* that describe:

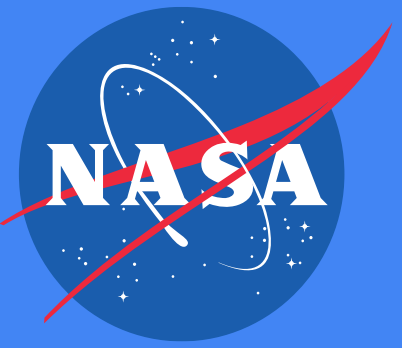
- An extreme design challenge or wicked problem that you/they are excited about
- A new method or approach related to extreme design or wicked problems
- New datasets, types of data capture, etc. that could advance such efforts
- Whatever new ideas this workshop has triggered for you!
- 10 mins per person

*** Our offer for your 1-pagers**

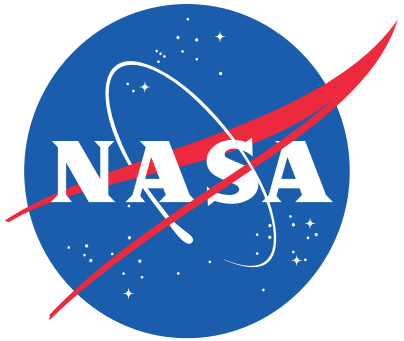
Exit Survey



Final Q&A



Thank you!



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August 15, 2022
St. Louis, MO