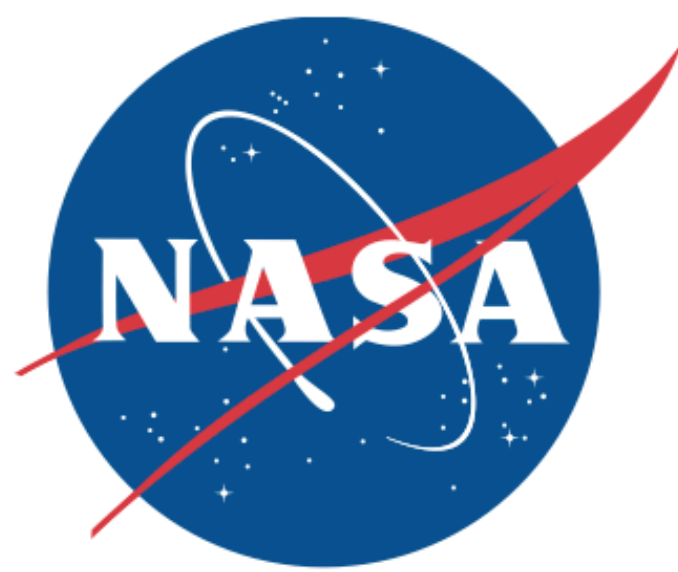


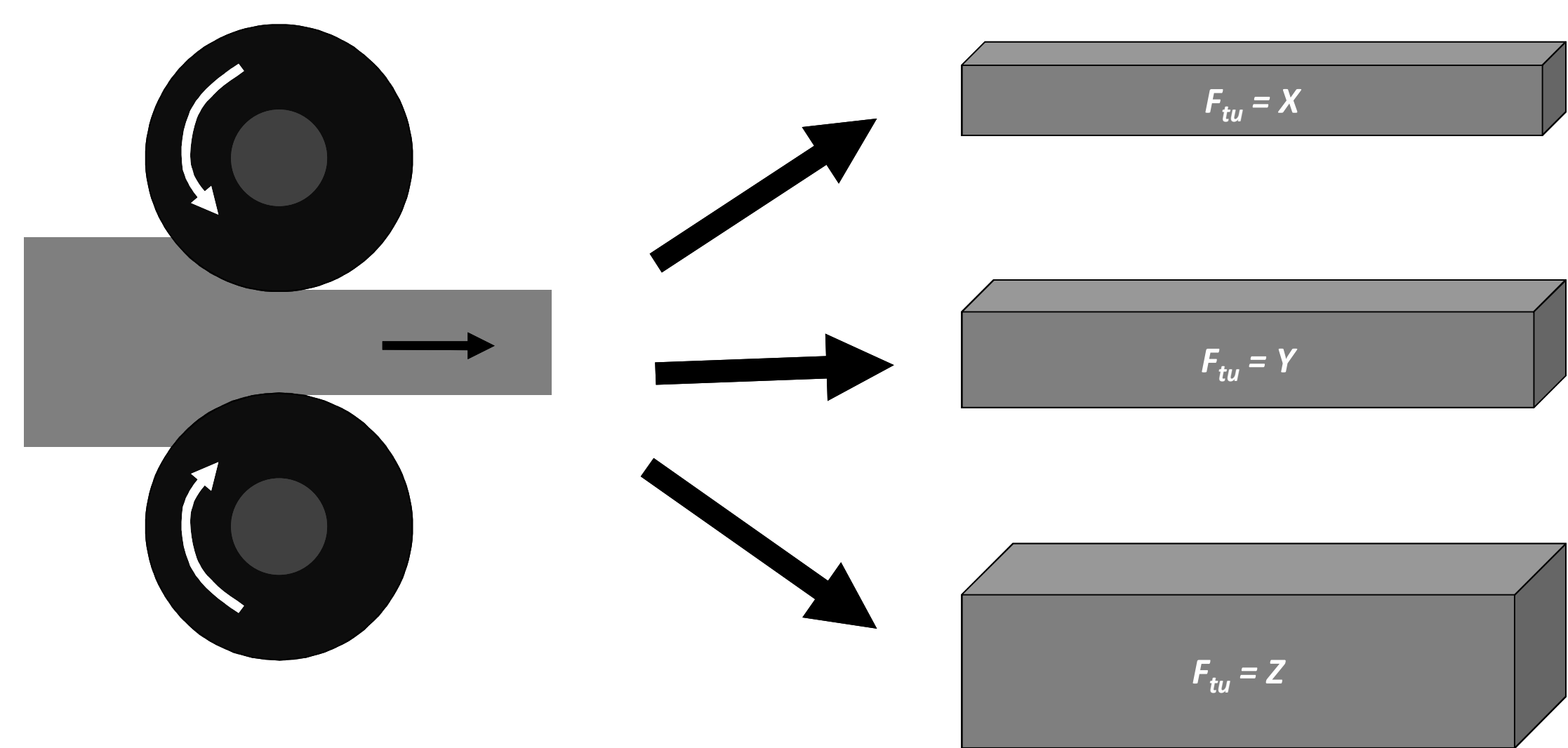
Unintended Consequences: How Qualification Constrains Innovation

Craig A. Brice
National Aeronautics and Space Administration
Langley Research Center, Hampton, VA USA



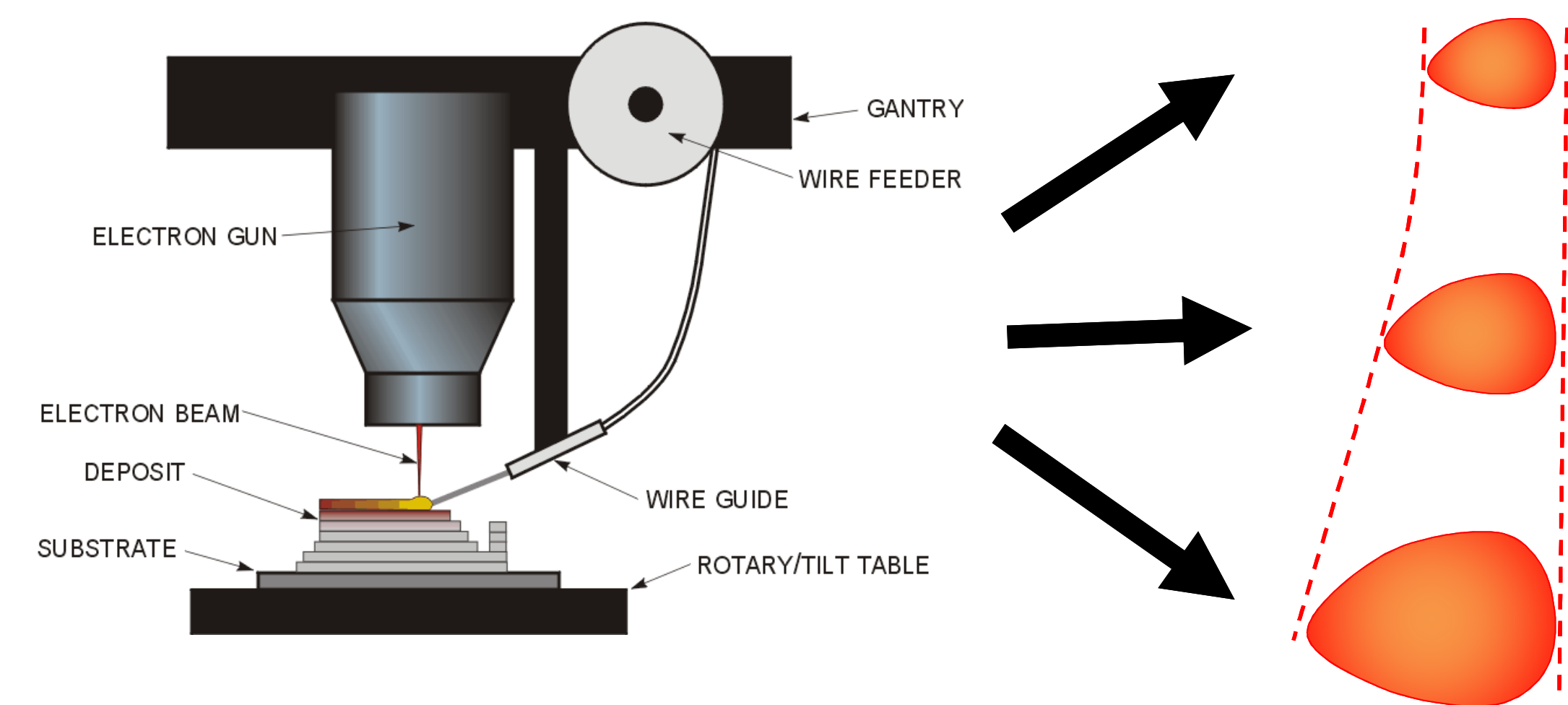
Aerospace structural metallic materials require a rigorous, expensive, and time consuming qualification procedure prior to their implementation onto an air vehicle system. This requirement creates a buffer that limits how quickly (if at all) promising new materials get introduced and fully adopted. The changing landscape of metallic material manufacturing creates a strong need for a fresh approach to qualification. The shift away from a process-specified approach towards an outcome-based approach will be necessary in order to take full advantage of benefits new manufacturing methods have to offer. The combination of additive manufacturing with computationally driven materials design holds tremendous promise to create revolutionary new materials. Consideration for how these new materials get into the marketplace must become a priority.

CURRENT STANDARD –WROUGHT PROCESSING



- Section size determines minimum design property values**
- Function of cooling rate dependent microstructure achieved during heat treatment
 - Minimum through-section property determines overall design value
 - Categorized into a few discrete section sizes

EMERGING TECHNOLOGY –ADDITIVE MANUFACTURING



- Molten pool size and associated cooling rate determines microstructure/properties, however:**
- There exists a continuum of molten pool sizes available for a given process
 - There are a wide range of similar but different processes producing the same output (laser, electron beam, etc.)
 - Fixing qualification requirements with a specific process and solidification range limits the usefulness of the process and becomes prohibitively expensive

The challenge for the additive manufacturing community is that the process segment of the process-microstructure-property relationship is not necessarily uniform or static. This implies the need for an outcome-based approach for material qualification. Currently, design minimum values are linked to a specific product form and often times further segmented based on section thickness. All of this is directly related to the microstructure (and indirectly to the resultant properties) though microstructure is not a governing criterion in the specification itself.

OUTCOME-BASED QUALIFICATION

The focus clearly needs to be on the outcome of the process, not the process itself. This is where computational methods can help by filling in the continuum in the process-microstructure-property relationship where data do not exist in order to predict subtle variations in the outcome of the process. For additive manufacturing to be truly successful on a large scale, the widespread use of computational modeling will be required in order to limit the testing burden for qualification and implementation.

