The Inspectability Metric: A Formalized System Of Measurement Enabling The Design For Inspection Framework

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Nondestructive evaluation (NDE) engineers are often confronted with structural design choices that present challenges to meeting inspection requirements. These challenges, at best, increase the resources needed to design an inspection solution and, at worst, require resource intensive redesign of the structure. If the inspectability of the structure can be determined early in the design cycle, these challenging inspection scenarios can be avoided. The emergence of additive manufacturing has further compounded this problem by enabling the creation of highly optimized structures with no regard to inspection constraints.

Design for inspection (DFI) offers a framework to integrate nondestructive evaluation (NDE) into the design process to alleviate the mechanisms that produce uninspectable designs. DFI is the concept of including inspectability in a multi-objective optimization framework so that it can be considered in parallel to other metrics such as mass and manufacturability. This approach allows rapid evaluation of the trade-off between design metrics to find solutions that meet the inspection needs of a particular material system, structural concept, or vehicle program. To enable DFI, there must be a system by which the inspectability of a structure can be measured. This system must be agile to produce results quickly, it must be versatile to work with the type of incomplete information one would encounter early in the design process (such as lack of inspection requirements), and it must be delivered in a form that is easily understood by designers.

To meet this need, this presentation introduces the novel inspectability metric as a system to measure inspectability. The inspectability metric is a standardized, automation friendly procedure that uses simulations to determine inspectability. Along with guidelines to properly process designs and integrate with existing workflows, the inspectability metric provides a suite of simulation tests to interrogate the ability to find defects and the sensitivity to variability. The testing rubric is designed to maximize the coverage of the parameter space while minimizing the number of simulations needed. The inspectability metric has been in development in collaboration with industry partners to ensure compatibility with modern simulation tools and aerospace design workflows.

In this study, we will demonstrate how the inspectability metric is able to determine the inspectability of multiple types of structures, including aerospace composites and additively manufactured parts. We will then show how the inspectability score can be plugged into existing design optimization tasks, such as structural sizing algorithms or design for manufacturing (DFM) frameworks.