

Mass Properties Engineering as a Systems Engineering Discipline

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Prologue

There has been an alarming trend for platform contractors to re-categorize Mass Properties away from Systems Engineering to other engineering disciplines, most prevalently categorizing Mass Properties Engineers as Mechanical Engineers. This is detrimental to the organization, and impacts the efficacy of the mass properties discipline as well as harming the platforms the contractors are endeavoring to produce.

Introduction

The discipline of Mass Properties Engineering is the engineering analog of what Internal Medicine is to medical practice. Both are specialties within their respective domains. Both concern themselves with the internal constituents of their respective spheres. And both must look at the whole body to fully characterize their impact. Neither Internal Medicine nor Mass Properties Engineering is held in the highest esteem, yet both are recognized as specialists who require additional training and expertise above and beyond general practice. As such, Specialists in Internal Medicine (Internists) and Mass Properties Engineers (MPEs) are set apart from ordinary doctors and engineers as necessary practitioners in their chosen fields.

While General Practitioners have the basic knowledge to understand the workings of the human body, and can determine certain malfunctions and prescribe remedies, they are limited in their detailed knowledge and lack the training and expertise that Internists have accumulated. There is a risk in utilizing a GP in diagnosing and treating a complex malady; therefore, a GP is trained to refer such patients on to a specialist like an Internist. Analogously, a mechanical engineer also has the basic knowledge to perform mass properties calculations such as adding weights or determining centers of gravity. However, this is insufficient to successfully complete the mass properties task. Performing a complete mass properties campaign requires a specialist in Mass Properties Engineering.

Treatise

Mass properties engineering is much more than running calculations. There is an entire litany of items that comprise the practice of mass properties

engineering that require MPEs to effectively accomplish the task. These include, but are not limited to the following items:

- Weight Control
- CG Control
- Moments and Products of Inertia Determination
- MOI and POI Control
- Mass Property Summations
- Mass Properties Uncertainty Analyses
- Mass Property Rotation and Displacement Analyses
- Support Equipment Requirement Determination
- Change Analyses
- Mass Property Configuration Control
- Mass Property Verification

What sets apart the practice of mass properties as performed by an MPE as opposed to the general practitioner of engineering is that the MPE examines the vehicle holistically, recognizing that it is this entire body that needs the mass properties to be controlled. If weight is the reigning constraint, it does little good to minimize the mass of a Signal Control Unit if this results in the addition of a large and complex Multiplexer (as an example). The vehicle body, its internal equipment, the required ancillary test and evaluation equipment, even the devices required to build the vehicle, are all part of a *System*, which the MPE needs to analyze and influence during the conception, design, building, and operation of the vehicle.

Because mass properties engineering is necessarily concerned with the whole system, and requires detailed knowledge of all the constituent components of the *System* as well as the *System* as a whole, the practice of mass properties engineering is by necessity a subset of the overarching concept of *Systems Engineering*. As stated in the NASA Systems Engineering Handbook (1995), ***“System engineering is a robust approach to the design, creation, and operation of systems. In simple terms, the approach consists of identification and quantification of system goals, creation of alternative system design concepts, performance of design trades, selection and implementation of the best design, verification that the design is properly built and integrated, and post-implementation assessment of how well the system meets (or met) the goals.”*** This definition succinctly describes what the practicing Mass Properties Engineer does every day throughout his or her career.

When individual MPEs in an organization are tasked with controlling the mass properties of a subset of the system, such as a subsystem or a section of a multi-section vehicle, the principles of Systems Engineering apply - *quantify the goals, examine alternative solutions and perform trades, select and implement the best design, then verify that the design is properly built while assessing the design before, during, and after implementation.*

The specialized knowledge of the MPE is called upon to ensure that these principles are implemented so that the system achieves the goals that management and customers have agreed upon.

Another aspect of the Systems Engineering Approach is that the MPE is an integral part of the product team. If the MPE determines that an individual aspect of the design

potentially compromises the system, then that MPE is obligated to raise the concern with the overall goal of the *system* in mind, offering suggested alternatives to allow the *system* to achieve its goals regardless of the impact on any component or subsystem. There is no place for parochialism with regards to an individual component or group of components when the entire *system's* function is at risk. This is a primary reason for placing the MPE squarely within the Systems Engineering group, to avoid divided loyalties and undue emphasis on one aspect of the *system*, such as structures and mechanisms by the mass properties group.

Epilogue

That the mass properties engineering tasks can best be accomplished when the MPE is the authority to analyze, quantify, trade, and verify across the entire system is almost a tautology. Just as the medical community and the patient needs the Internist to diagnose and treat the whole body simultaneously with the individual organs, a product's engineering team requires the Mass Properties Engineer to simultaneously analyze, quantify, trade, and verify the entire *System* and its constituents. Constraining the MPE within a subset of product engineering disciplines will stifle the freedom the *System* requires of the mass properties engineer in order for him to best perform his duties. To do so undermines the systems engineering process and harms the end product, the contractor, and the customer.