National Aeronautics and Space Administration

Marshall Space Flight Center

Systems Analysis

Mass Uncertainty and Application For Space Systems

To be Presented at 2013 Society of Allied Weight Engineers Annual Conference, St. Louis Mo.

Current S-120 Terminology

Table 1 — Mass Growth Allowance and Depletion Schedule

Major Category	Maturity Code	Design Maturity (Basis for Mass Determination)	Mass Growth Allowance (%)													
			Electrical/Electronic Components			Structure	Brackets, Clips, Hardware	Battery	Solar Array	Thermal Control	Mechanisms	Propulsion	Wire Harness	Instrumentation	ECLSS, Crew Systems
			0-5 kg	5-15 kg	>15 kg										
E	1	**Estimated** 1) an approximation based on rough sketches, parametric analysis, or undefined requirements, 2) a guess based on experience, 3) a value with unknown basis or pedigree.	30	25	20	25	30	25	30	25	25	25	55	55	23
	2	**Layout** 1) a calculation or approximation based on conceptual designs (equivalent to layout drawings), 2) major modifications to existing hardware	25	20	15	15	20	15	20	20	15	15	30	30	15
C	3	**Preliminary Design** 1) calculations based on a new design after initial sizing but prior to final structural or thermal analysis, 2) minor modification of existing hardware	20	15	10										
	4	**Released Design** 1) calculations based on a design after final signoff and release for procurement or production, 2) very minor modification of existing hardware, 3) catalog value	10	5	5										
A	5	**Existing Hardware** 1) actual mass from another program, assuming that hardware will satisfy the requirements of the current program with no changes, 2) values based on measured masses of qualification hardware	3	3	3										
	6	**Actual Mass** measured hardware	No mass grow												
	7	**Customer Furnished Equipment or Specification Value**	Typically a "not-t												

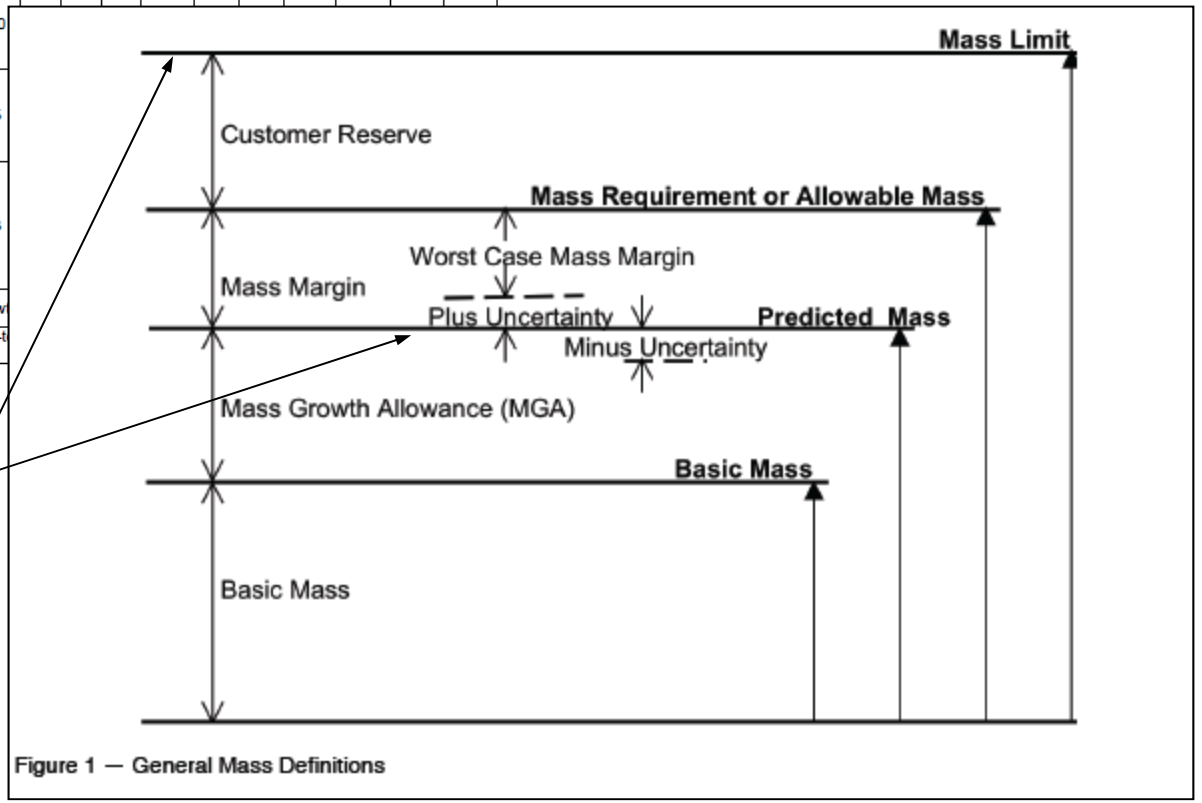


Figure 1 — General Mass Definitions

Ambiguity on specification: NTE or nominal

Ambiguity on 'Uncertainty': A5 or A6

A5 and A6 are important distinctions for business and operations

Ambiguity hurts customer (internal and external)

Mass Growth Allowance (MGA) EXAMPLE

Major Category	Code	Design Maturity (Basis for Mass Determination)	Mass Growth Allowance (MGA%)														
			Electrical, Electronic Components			Composite Structure	Metal Structure	Brackets, Clips, Hardware	Battery	Solar Array	Thermal Control	Mechanisms	Propulsion	Wire Harness	Instrumentation	ECLSS, Crew Systems	
			0–5 kg	5–15 kg	> 15 kg												
E	1	**Estimated** 1) An approximation based on rough sketches, parametric analysis, or undefined requirements, 2) a guess based on experience, or 3) a value with unknown basis or pedigree.	30	20	15	18	18	30	20	20	18	18	18	50	50	23	← Undefined Loads
	2	**Layout** 1) A calculation or approximation based on conceptual designs (equivalent to layout drawings), 2) major modifications to existing hardware	25	20	15	12	12	20	15	15	12	12	12	30	30	15	← After SDR, Before PDR
C	3	**Preliminary Design** 1) Calculations based on a new design after initial sizing but prior to final structural or thermal analysis, 2) minor modification of existing hardware	20	15	10	9	8	15	10	10	8	8	8	25	25	10	← After PDR, Before CDR
	4	**Released Design** 1) Calculations based on a design after final signoff and release for procurement or production, 2) very minor modification of existing hardware, 3) catalog value	10	5	5	6	4	6	5	5	4	4	4	10	10	6	← Test articles good, Production drawings
A	5	**Existing Hardware** 1) Actual mass from another program, assuming that hardware will satisfy the requirements of the current program with no changes, 2) values substituted based on measured masses of qualification or production hardware	3	3	3	4	2	3	3	3	2	2	2	6	6	4	← Current inventory, (% replaced by known variation)
	6	**Actual Mass** Measured hardware	No mass growth allowance (use appropriate uncertainty values)														← Tagged Hardware
	7	**Customer Furnished Equipment or Specification Value**	Typically a "not-to-exceed" value is provided; however, contractor has the option to include MGA if justified														

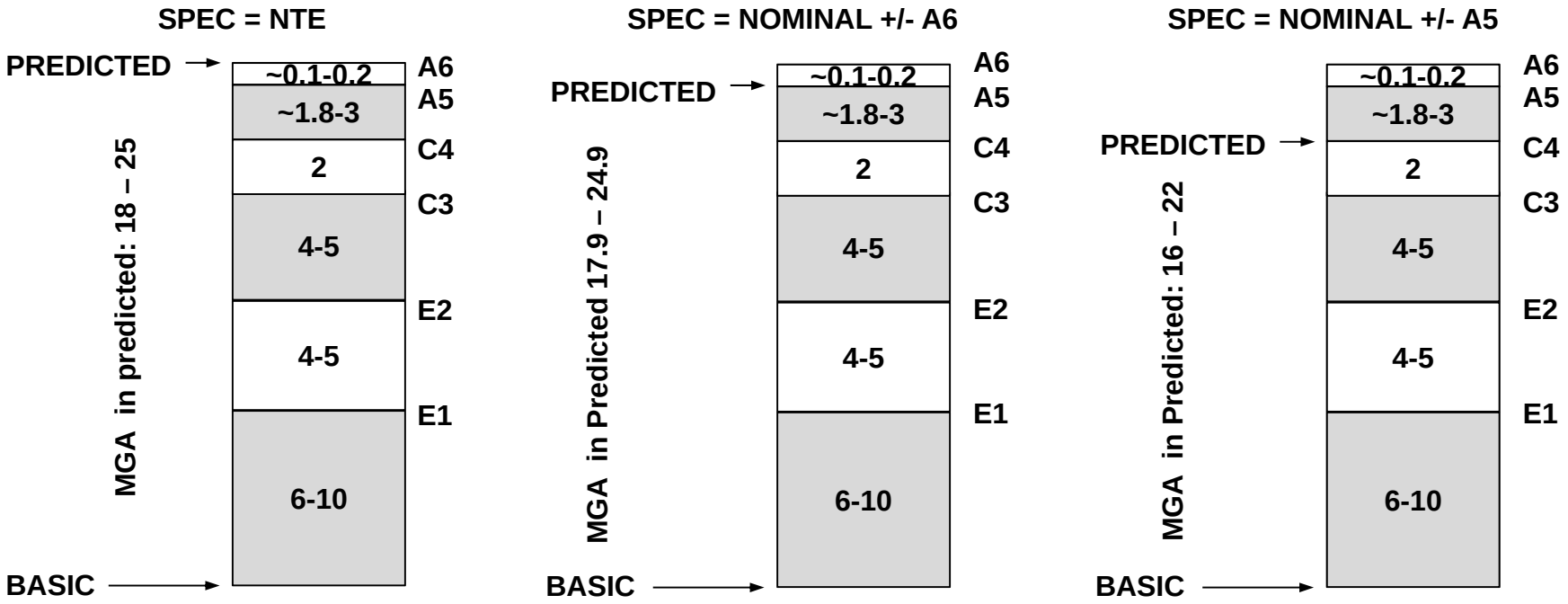
MGA schedule derived from S-120 and R-020A

MGA applied at lowest level of detail available-component

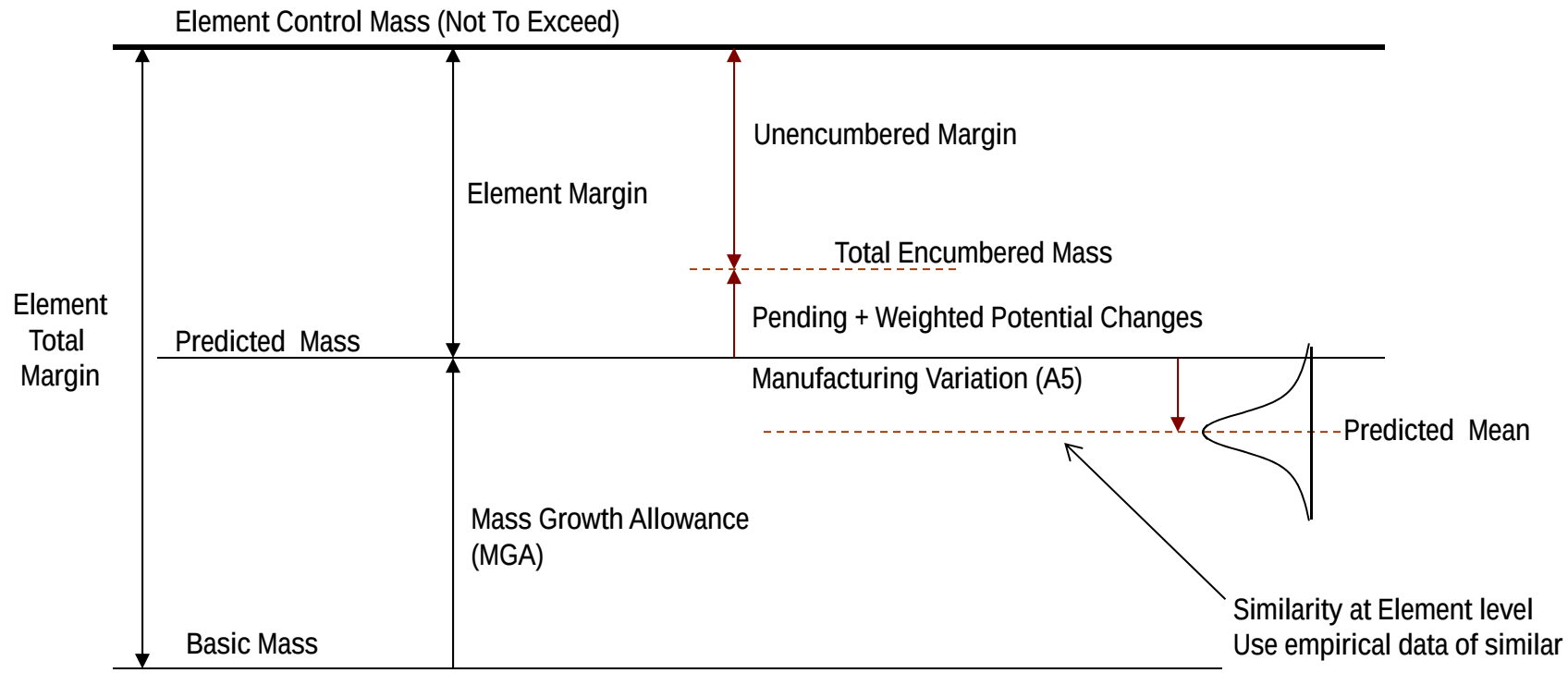
MGA and Specification Correlation

Expected development maturity under contract (spec) should correlate with Project/ Program Approved MGA Depletion Schedule in Mass Properties Control Plan

- **If specification NTE, MGA is inclusive of Actual MGA (A5 & A6)**
- **If specification is not an NTE Actual MGA (e.g. nominal), then MGA values are reduced by A5 values and A5 is representative of remaining uncertainty**



Terminology: Dry Mass



Basic Mass = Engineering Estimate based on design and construction principles with NO embedded margin

MGA Mass = Basic Mass * assessed % from approved MGA schedule

Predicted Mass = Basic + MGA

Aggregate MGA % = (Aggregate Predicted – Aggregate Basic) / Aggregate Basic

Recommendation

- **If Specification is NTE, MGA is inclusive of Actual MGA (A5 & A6)**

- **If Specification is for nominal mass then ALL Estimated & Calculated MGA values are reduced by A5 values**

  … and A5 is representative of remaining uncertainty