



International Council on Systems Engineering
A better world through a systems approach

Model-Based Certification Methodology

Jay Silverman



Jay Silverman

Principal Systems and Project Manager



Professional experience

Jay Silverman has been working as a systems engineer for over 15 years. He is currently working as the Principal Systems and Project Engineering Manager for Firehawk Aerospace, having most recently worked for 6 years as a Sr. Manager of Systems Engineering at Raytheon. He is currently pursuing his PhD in Systems Engineering at Old Dominion University.

Expertise

- Member of the INCOSE RWG
- Co-Author of Guide to Model-Based Needs and Requirements

Agenda

- Model-Based Certification (MBC)
- MBC Meta-Model
- Regulatory Modeling Framework
- Certification Planning Framework
- Certification Example

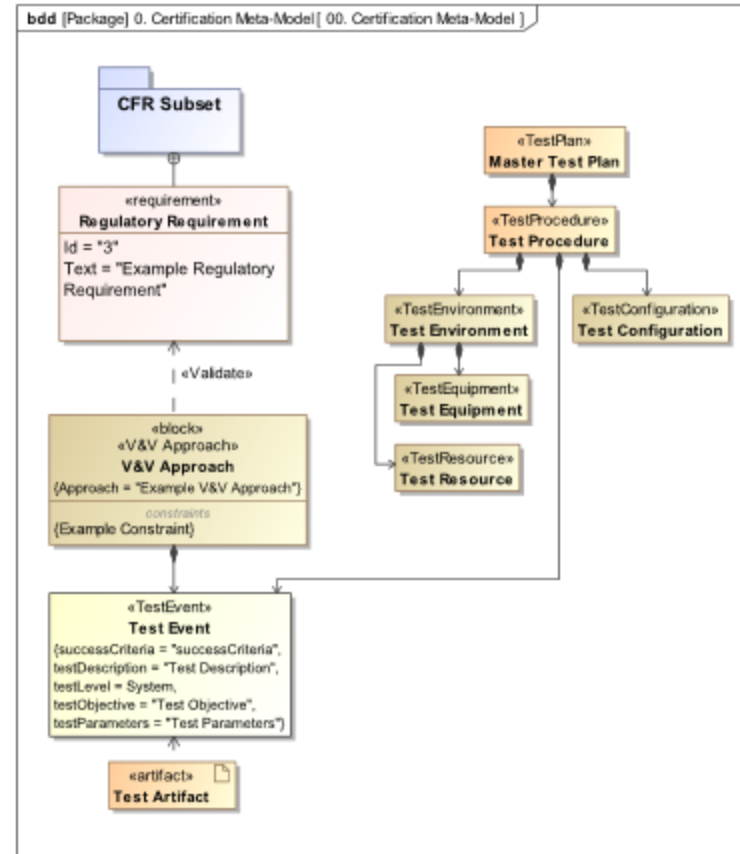
Model-Based Certification

- Capture System Certification Plan and Results in MBSE Model
- Provide System Model to Certify System to Certification Body
- Single Source of Truth for System
- Complete Digital Twin

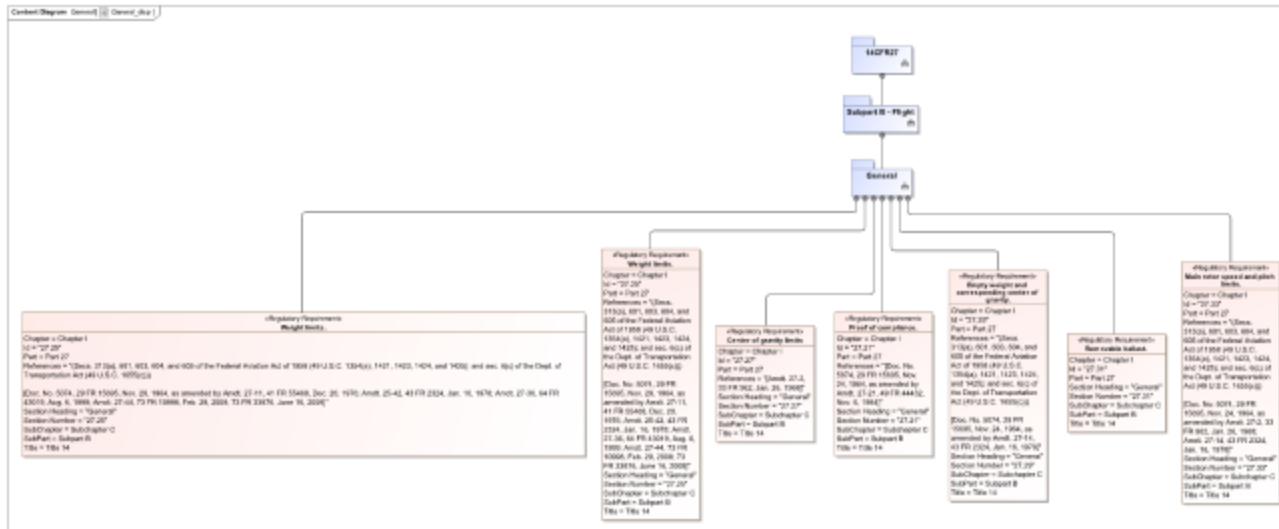
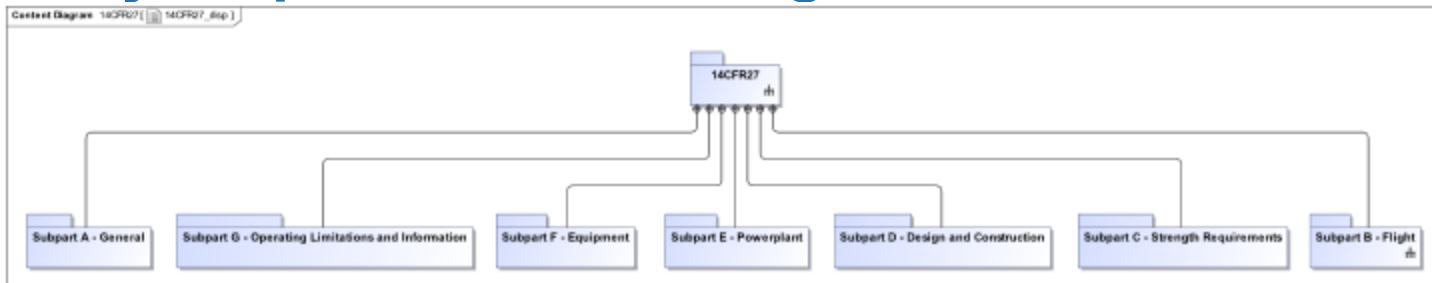


MBC Meta-Model

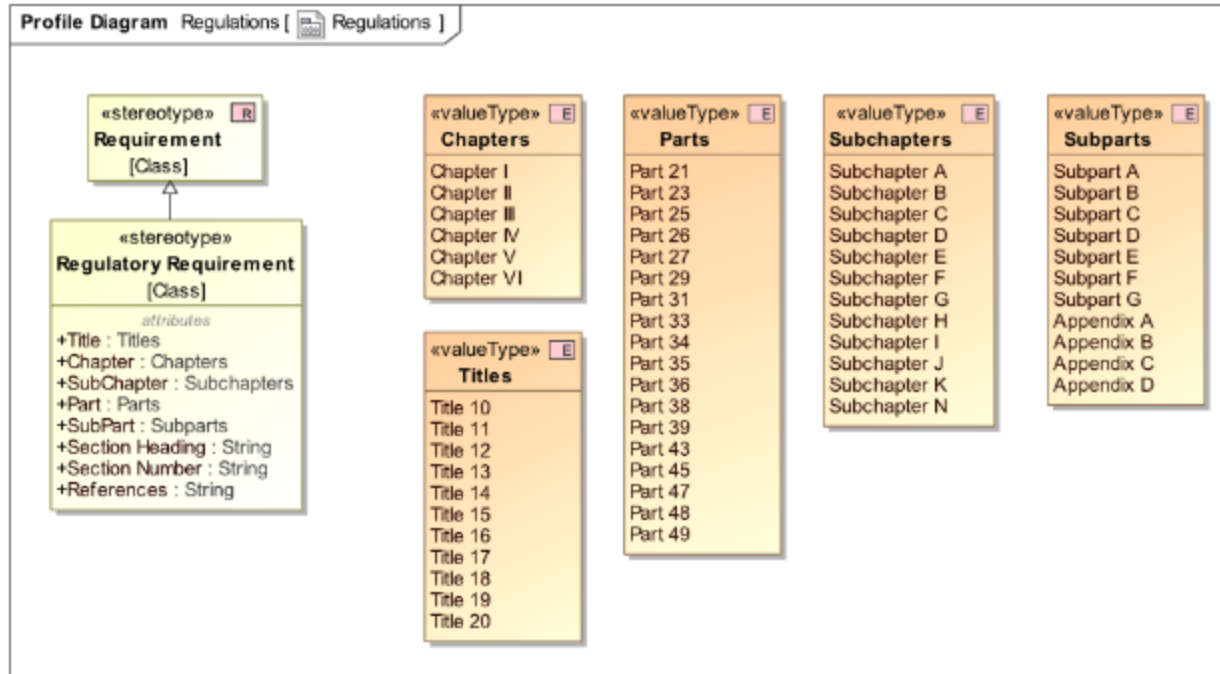
- Model Regulatory Requirements
- Capture V&V Approaches
- Model Certification/Test Plan
- Capture Test Results
- Bi-directional traceability from requirements to test results
- Single Source of Truth for all System Certification Activities
- Results in Certification Package



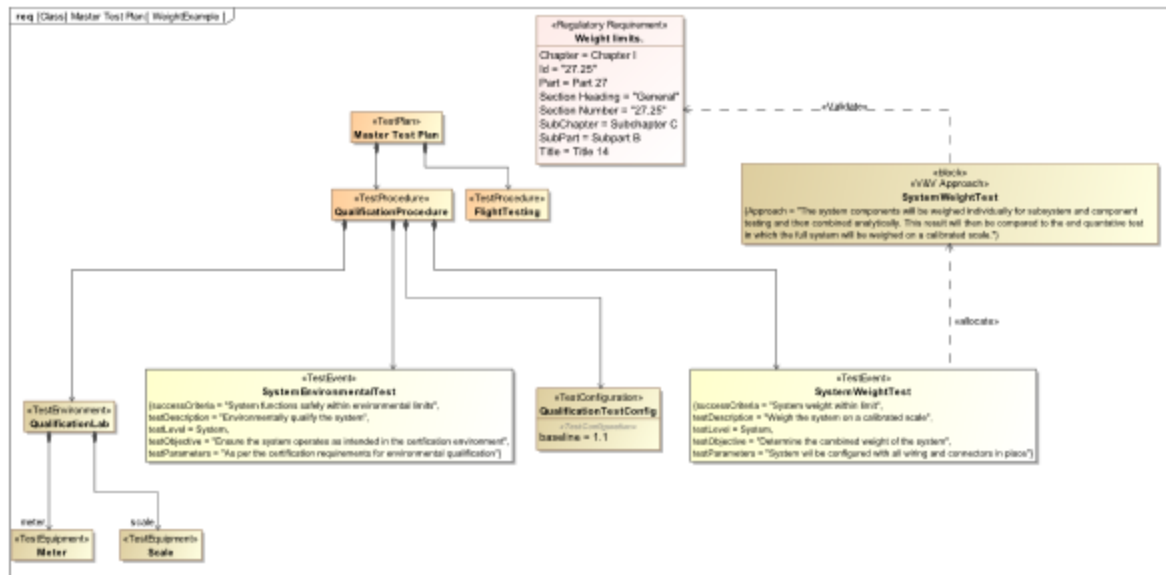
Regulatory Requirement Modeling



Regulatory Customizations

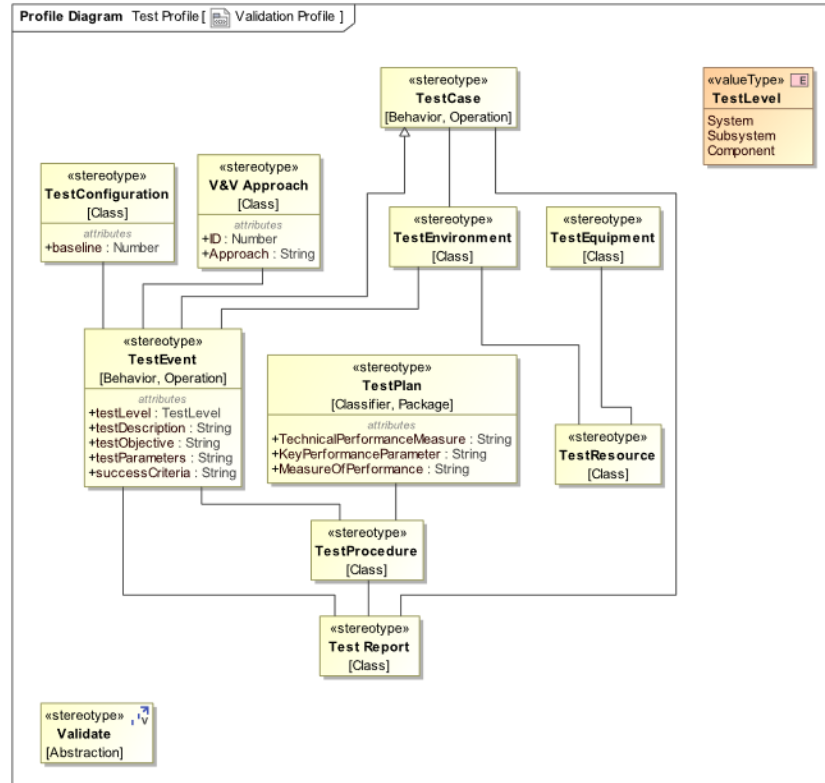


Certification Planning

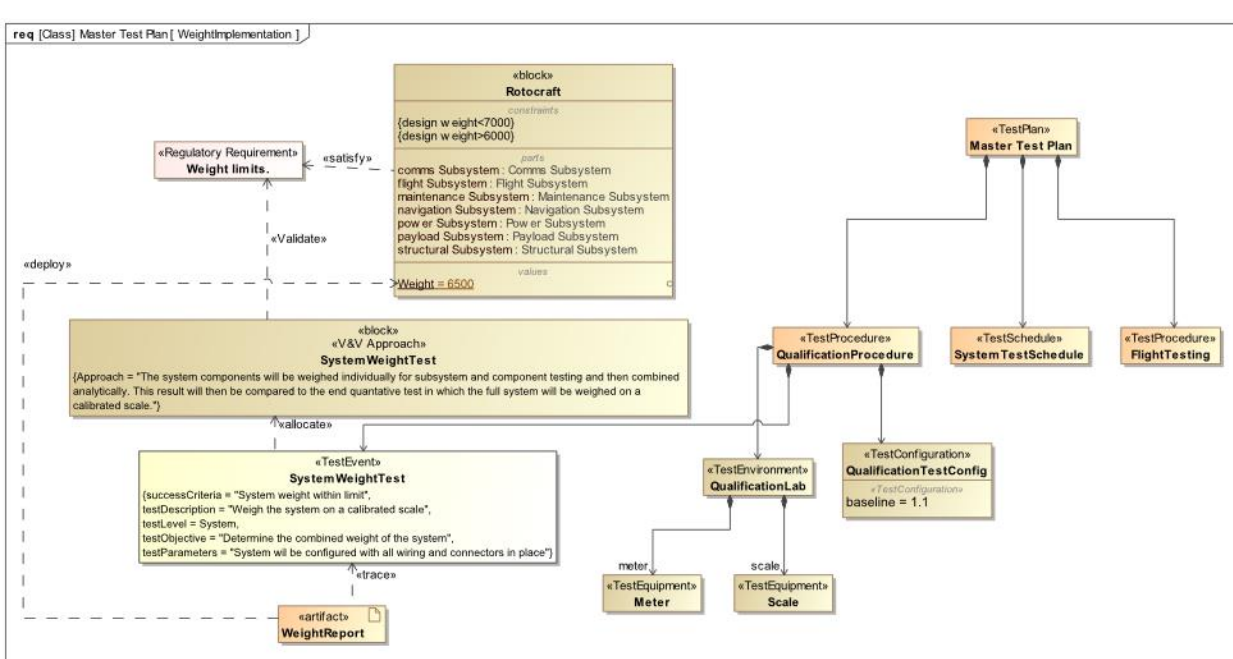


#	Name	Test	Validation Approach	Test Event
1	27.25 Weight Limits	Each requirement of this subject must be met in each applicable combination of weight and center of gravity within the larger of loading conditions for certification is requested. The test is shown:		<ul style="list-style-type: none">① Check center of gravity② Qualification loading③ Loading in test flight④ Run weight flight test⑤ Offnominal flight test⑥ Qualification approach⑦ Qualification test⑧ System Environmental Test⑨ System Weight Test⑩ Qualification test⑪ System Weight Test
12	27.27 Proof of compliance	<p>(a) The systematic investigation of each required combination of weight and center of gravity compliance can be by secondary selected from combinations investigated.</p> <p>(b) Maximum weight. The maximum weight (the highest weight at which compliance with each applicable requirement of this part is shown) must be established as that is—</p> <ul style="list-style-type: none">(1) Not more than—(i) The highest weight authorized by the applicant.(ii) The design maximum weight (the highest weight at which compliance with each applicable structural loading condition of this part is shown), or(iii) The highest weight at which compliance with each applicable flight requirement of this part is shown, or(iv) The highest weight in which the provisions of 27.27 (a) or 27.180 (c), or combinations thereof, are demonstrated if the weights and loading conditions and/or design provided by these requirements can be met, and(v) Not less than the actual—(i) The empty weight determined under 27.23, and(ii) The weight of usable fuel appropriate for the intended operation with full payload. <p>(c) For each tank, or compartment weight of 150 pounds or any lower weight for which certification is requested.</p> <p>(d) Minimum weight. The minimum weight (the lowest weight at which compliance with each applicable requirement of this part is shown) must be established as that is—</p> <ul style="list-style-type: none">(1) Not more than the actual—(i) The empty weight determined under 27.23, and(ii) The weight of the minimum crew required to operate the aircraft, allowing for each crew member's weight more than 175 pounds, or any lower weight selected by the applicant or included in the loading provisions; and(2) Not less than—(i) The lowest weight selected by the applicant.(ii) The design minimum weight (the lowest weight at which compliance with each applicable structural loading condition of this part is shown), or(iii) The lowest weight at which compliance with each applicable flight requirement of this part is shown. <p>(e) Full weight and payload weight control. If a full weight for the subject with a payload weight not less than that in greater than the minimum weight established under paragraph (d) of this section may be established for any subsequent certification—</p> <ul style="list-style-type: none">(1) The structural load combination does not include human external cargo.(2) The structural crew payload approach for external load operators under 27.173 (b) is used regardless of operational standards is obtained.(3) The position of the full weight that is greater than the maximum weight established in paragraph (d) of this section is made up of the weight of all crew and payload external load.(4) Structural crew payload with external cargo is shown to comply with the applicable structural requirements of this part under the increased loads and stresses caused by the weight increase over the established weight paragraph (d) of this section, and(5) Operation of the subject with a full weight (greater than the maximum weight established under paragraph (d) of this section) is limited by appropriate operating limitations under 27.405 (a) and (b) of this part.(6) The subject is tested with all centers of gravity and all external loads, the external load of center of gravity must be established for each weight combination under 27.23, such as minimum crew payload.	<ul style="list-style-type: none">① System Weight Test② System Weight Test③ System Weight Test④ System Weight Test⑤ System Weight Test⑥ System Weight Test⑦ System Weight Test⑧ System Weight Test⑨ System Weight Test⑩ System Weight Test⑪ System Weight Test	
13	27.28 Weight limits	<p>(a) The maximum weight (the highest weight at which compliance with each applicable requirement of this part is shown) must be established as that is—</p> <ul style="list-style-type: none">(1) Not more than—(i) The highest weight authorized by the applicant.(ii) The design maximum weight (the highest weight at which compliance with each applicable structural loading condition of this part is shown), or(iii) The highest weight at which compliance with each applicable flight requirement of this part is shown, or(iv) The highest weight in which the provisions of 27.27 (a) or 27.180 (c), or combinations thereof, are demonstrated if the weights and loading conditions and/or design provided by these requirements can be met, and(v) Not less than the actual—(i) The empty weight determined under 27.23, and(ii) The weight of usable fuel appropriate for the intended operation with full payload. <p>(c) For each tank, or compartment weight of 150 pounds or any lower weight for which certification is requested.</p> <p>(d) Minimum weight. The minimum weight (the lowest weight at which compliance with each applicable requirement of this part is shown) must be established as that is—</p> <ul style="list-style-type: none">(1) Not more than the actual—(i) The empty weight determined under 27.23, and(ii) The weight of the minimum crew required to operate the aircraft, allowing for each crew member's weight more than 175 pounds, or any lower weight selected by the applicant or included in the loading provisions; and(2) Not less than—(i) The lowest weight selected by the applicant.(ii) The design minimum weight (the lowest weight at which compliance with each applicable structural loading condition of this part is shown), or(iii) The lowest weight at which compliance with each applicable flight requirement of this part is shown. <p>(e) Full weight and payload weight control. If a full weight for the subject with a payload weight not less than that in greater than the minimum weight established under paragraph (d) of this section may be established for any subsequent certification—</p> <ul style="list-style-type: none">(1) The structural load combination does not include human external cargo.(2) The structural crew payload approach for external load operators under 27.173 (b) is used regardless of operational standards is obtained.(3) The position of the full weight that is greater than the maximum weight established in paragraph (d) of this section is made up of the weight of all crew and payload external load.(4) Structural crew payload with external cargo is shown to comply with the applicable structural requirements of this part under the increased loads and stresses caused by the weight increase over the established weight paragraph (d) of this section, and(5) Operation of the subject with a full weight (greater than the maximum weight established under paragraph (d) of this section) is limited by appropriate operating limitations under 27.405 (a) and (b) of this part.(6) The subject is tested with all centers of gravity and all external loads, the external load of center of gravity must be established for each weight combination under 27.23, such as minimum crew payload.	<ul style="list-style-type: none">① System Weight Test② System Weight Test③ System Weight Test④ System Weight Test⑤ System Weight Test⑥ System Weight Test⑦ System Weight Test⑧ System Weight Test⑨ System Weight Test⑩ System Weight Test⑪ System Weight Test	
14	27.29 Center of gravity limits	<p>(a) The maximum weight (the highest weight at which compliance with each applicable requirement of this part is shown) must be established as that is—</p> <ul style="list-style-type: none">(1) Not more than—(i) The highest weight authorized by the applicant.(ii) The design maximum weight (the highest weight at which compliance with each applicable structural loading condition of this part is shown), or(iii) The highest weight at which compliance with each applicable flight requirement of this part is shown, or(iv) The highest weight in which the provisions of 27.27 (a) or 27.180 (c), or combinations thereof, are demonstrated if the weights and loading conditions and/or design provided by these requirements can be met, and(v) Not less than the actual—(i) The empty weight determined under 27.23, and(ii) The weight of usable fuel appropriate for the intended operation with full payload. <p>(c) For each tank, or compartment weight of 150 pounds or any lower weight for which certification is requested.</p> <p>(d) Minimum weight. The minimum weight (the lowest weight at which compliance with each applicable requirement of this part is shown) must be established as that is—</p> <ul style="list-style-type: none">(1) Not more than the actual—(i) The empty weight determined under 27.23, and(ii) The weight of the minimum crew required to operate the aircraft, allowing for each crew member's weight more than 175 pounds, or any lower weight selected by the applicant or included in the loading provisions; and(2) Not less than—(i) The lowest weight selected by the applicant.(ii) The design minimum weight (the lowest weight at which compliance with each applicable structural loading condition of this part is shown), or(iii) The lowest weight at which compliance with each applicable flight requirement of this part is shown. <p>(e) Full weight and payload weight control. If a full weight for the subject with a payload weight not less than that in greater than the minimum weight established under paragraph (d) of this section may be established for any subsequent certification—</p> <ul style="list-style-type: none">(1) The structural load combination does not include human external cargo.(2) The structural crew payload approach for external load operators under 27.173 (b) is used regardless of operational standards is obtained.(3) The position of the full weight that is greater than the maximum weight established in paragraph (d) of this section is made up of the weight of all crew and payload external load.(4) Structural crew payload with external cargo is shown to comply with the applicable structural requirements of this part under the increased loads and stresses caused by the weight increase over the established weight paragraph (d) of this section, and(5) Operation of the subject with a full weight (greater than the maximum weight established under paragraph (d) of this section) is limited by appropriate operating limitations under 27.405 (a) and (b) of this part.(6) The subject is tested with all centers of gravity and all external loads, the external load of center of gravity must be established for each weight combination under 27.23, such as minimum crew payload.	<ul style="list-style-type: none">① System Weight Test② System Weight Test③ System Weight Test④ System Weight Test⑤ System Weight Test⑥ System Weight Test⑦ System Weight Test⑧ System Weight Test⑨ System Weight Test⑩ System Weight Test⑪ System Weight Test	
15	27.30 Empty weight and center	<p>(a) The maximum weight (the highest weight at which compliance with each applicable requirement of this part is shown) must be established as that is—</p> <ul style="list-style-type: none">(1) Not more than—(i) The highest weight authorized by the applicant.(ii) The design maximum weight (the highest weight at which compliance with each applicable structural loading condition of this part is shown), or(iii) The highest weight at which compliance with each applicable flight requirement of this part is shown, or(iv) The highest weight in which the provisions of 27.27 (a) or 27.180 (c), or combinations thereof, are demonstrated if the weights and loading conditions and/or design provided by these requirements can be met, and(v) Not less than the actual—(i) The empty weight determined under 27.23, and(ii) The weight of usable fuel appropriate for the intended operation with full payload. <p>(c) For each tank, or compartment weight of 150 pounds or any lower weight for which certification is requested.</p> <p>(d) Minimum weight. The minimum weight (the lowest weight at which compliance with each applicable requirement of this part is shown) must be established as that is—</p> <ul style="list-style-type: none">(1) Not more than the actual—(i) The empty weight determined under 27.23, and(ii) The weight of the minimum crew required to operate the aircraft, allowing for each crew member's weight more than 175 pounds, or any lower weight selected by the applicant or included in the loading provisions; and(2) Not less than—(i) The lowest weight selected by the applicant.(ii) The design minimum weight (the lowest weight at which compliance with each applicable structural loading condition of this part is shown), or(iii) The lowest weight at which compliance with each applicable flight requirement of this part is shown. <p>(e) Full weight and payload weight control. If a full weight for the subject with a payload weight not less than that in greater than the minimum weight established under paragraph (d) of this section may be established for any subsequent certification—</p> <ul style="list-style-type: none">(1) The structural load combination does not include human external cargo.(2) The structural crew payload approach for external load operators under 27.173 (b) is used regardless of operational standards is obtained.(3) The position of the full weight that is greater than the maximum weight established in paragraph (d) of this section is made up of the weight of all crew and payload external load.(4) Structural crew payload with external cargo is shown to comply with the applicable structural requirements of this part under the increased loads and stresses caused by the weight increase over the established weight paragraph (d) of this section, and(5) Operation of the subject with a full weight (greater than the maximum weight established under paragraph (d) of this section) is limited by appropriate operating limitations under 27.405 (a) and (b) of this part.(6) The subject is tested with all centers of gravity and all external loads, the external load of center of gravity must be established for each weight combination under 27.23, such as minimum crew payload.	<ul style="list-style-type: none">① System Weight Test② System Weight Test③ System Weight Test④ System Weight Test⑤ System Weight Test⑥ System Weight Test⑦ System Weight Test⑧ System Weight Test⑨ System Weight Test⑩ System Weight Test⑪ System Weight Test	

Certification Customizations



Certification Package



#	Id	Name	Type	Validation Approach	Test Case	Success Criteria	Test Results
1	1.1	Master Test Plan	Test Plan				
2	2.1	Master Test Plan	Test Plan				
3	3.1	Master Test Plan	Test Plan				
4	4.1	Master Test Plan	Test Plan				
5	5.1	Master Test Plan	Test Plan				
6	6.1	Master Test Plan	Test Plan				
7	7.1	Master Test Plan	Test Plan				
8	8.1	Master Test Plan	Test Plan				
9	9.1	Master Test Plan	Test Plan				
10	10.1	Master Test Plan	Test Plan				
11	11.1	Master Test Plan	Test Plan				
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