HSM Analysis Interface Module (AIM)

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0.1 Introduction . . . 1
0.1.1 HSM AIM Overview . . . 1
0.2 AIM Inputs . . . 1
0.3 AIM Outputs . . . 1
0.4 FEA Material . . . 2
0.4.1 JSON String Dictionary . . . 2
0.4.2 Single Value String . . . 2
0.5 FEA Property . . . 2
0.5.1 JSON String Dictionary . . . 2
0.5.2 Single Value String . . . 3
0.6 FEA Constraint . . . 3
0.6.1 JSON String Dictionary . . . 3
0.6.2 Single Value String . . . 3
0.7 FEA Support . . . 3
0.7.1 JSON String Dictionary . . . 3
0.7.2 Single Value String . . . 4
0.8 FEA Connection . . . 4
0.8.1 JSON String Dictionary . . . 4
0.8.2 Single Value String . . . 4
0.9 FEA Load . . . 4
0.9.1 JSON String Dictionary . . . 4
0.9.2 Single Value String . . . 5
0.10 FEA Analysis . . . 5
0.10.1 JSON String Dictionary . . . 5
0.10.2 Single Value String . . . 5
0.11 FEA Design Variables . . . 6
0.11.1 JSON String Dictionary . . . 6
0.12 FEA DesignVariableRelation . . . 6
0.12.1 JSON String Dictionary . . . 6
0.13 FEA Design Constraints . . . 6
0.13.1 JSON String Dictionary . . . 6
0.14 FEA Optimization Control . . . 6
0.15 FEA Mass Increments . . . 6
0.16 FEA Design Equations . . . 7
0.16.1 List of equation strings . . . 7
0.17 FEA Table Constants . . . 7
0.18 FEA Design Responses . . . 7
0.18.1 JSON String Dictionary . . . 7
0.19 FEA Design Equation Responses . . . 7
0.19.1 JSON String Dictionary . . . 7
0.20 FEA Design Optimization Parameters . . . 7
0.21 FEA Aerodynamic References . . . 8

0.21.1 JSON String Dictionary 8

0.1 Introduction

0.1.1 HSM AIM Overview

A module in the Computational Aircraft Prototype Syntheses (CAPS) has been developed to interact with the Hybrid Shell Model (HSM) code developed Mark Drela [MIT Department of Aeronautics & Astronautics].

An outline of the AIM's inputs and outputs are provided in AIM Inputs and AIM Outputs, respectively.

0.2 AIM Inputs

The following list outlines the HSM options along with their default value available through the AIM interface.

- **Proj_Name = "hsm_CAPS"**
  This corresponds to the project name used for file naming.
- **Tess_Params = [0.025, 0.001, 15.0]**
  Body tessellation parameters used when creating a boundary element model. Tess_Params[0] and Tess↩_Params[1] get scaled by the bounding box of the body. (From the EGADS manual) A set of 3 parameters that drive the EDGE discretization and the FACE triangulation. The first is the maximum length of an EDGE segment or triangle side (in physical space). A zero is flag that allows for any length. The second is a curvature-based value that looks locally at the deviation between the centroid of the discrete object and the underlying geometry. Any deviation larger than the input value will cause the tessellation to be enhanced in those regions. The third is the maximum interior dihedral angle (in degrees) between triangle facets (or Edge segment tangents for a WIREBODY tessellation), note that a zero ignores this phase
- **Edge_Point_Min = 2**
  Minimum number of points on an edge including end points to use when creating a surface mesh (min 2).
- **Edge_Point_Max = 50**
  Maximum number of points on an edge including end points to use when creating a surface mesh (min 2).
- **Quad_Mesh = False**
  Create a quadratic mesh on four edge faces when creating the boundary element model.
- **Property = NULL**
  Property tuple used to input property information for the model, see FEA Property for additional details.
- **Material = NULL**
  Material tuple used to input material information for the model, see FEA Material for additional details.
- **Constraint = NULL**
  Constraint tuple used to input constraint information for the model, see FEA Constraint for additional details.
- **Load = NULL**
  Load tuple used to input load information for the model, see FEA Load for additional details.
- **Mesh = NULL**
  A Mesh link.

0.3 AIM Outputs

The following list outlines the HSM AIM outputs available through the AIM interface.

- **None**

0.4 FEA Material

Structure for the material tuple = ("Material Name", "Value"). "Material Name" defines the reference name for the material being specified. The "Value" can either be a JSON String dictionary (see Section JSON String Dictionary) or a single string keyword (see Section Single Value String).

0.4.1 JSON String Dictionary

If "Value" is JSON string dictionary (e.g. "Value" = {"density": 7850, "youngModulus": 120000.0, "poissonRatio": 0.5, "materialType": "isotropic"}) the following keywords (= default values) may be used:

- **materialType = "Isotropic"**
  Material property type. Options: Isotropic, Anisothotropic, Orthotropic, or Anisotropic.

- **youngModulus = 0.0**
  Also known as the elastic modulus, defines the relationship between stress and strain. Default if 'shear↩ Modulus' and 'poissonRatio' != 0, youngModulus = 2∗(1+poissonRatio)∗shearModulus

- **shearModulus = 0.0**
  Also known as the modulus of rigidity, is defined as the ratio of shear stress to the shear strain. Default if 'youngModulus' and 'poissonRatio' != 0, shearModulus = youngModulus/(2∗(1+poissonRatio))

- **poissonRatio = 0.0**
  The fraction of expansion divided by the fraction of compression. Default if 'youngModulus' and 'shear↩ Modulus' != 0, poissonRatio = (2∗youngModulus/shearModulus) - 1

- **density = 0.0**
  Density of the material.

0.4.2 Single Value String

If "Value" is a string, the string value may correspond to an entry in a predefined material lookup table. NOT YET IMPLEMENTED!!!!

0.5 FEA Property

Structure for the property tuple = ("Property Name", "Value"). "Property Name" defines the reference `caps↩ Group` for the property being specified. The "Value" can either be a JSON String dictionary (see Section JSON String Dictionary) or a single string keyword (see Section Single Value String).

0.5.1 JSON String Dictionary

If "Value" is JSON string dictionary the following keywords (= default values) may be used:

- **massPerLength = 0.0**
  Mass per unit length.

- **massPerArea = 0.0**
  Mass per unit area.

0.5.2 Single Value String

If "Value" is a string, the string value may correspond to an entry in a predefined property lookup table. NOT YET IMPLEMENTED!!!!

0.6 FEA Constraint

Structure for the constraint tuple = ("Constraint Name", "Value"). "Constraint Name" defines the reference name for the constraint being specified. The "Value" can either be a JSON String dictionary (see Section JSON String Dictionary) or a single string keyword (see Section Single Value String).

0.6.1 JSON String Dictionary

If "Value" is JSON string dictionary (eg. "Value" = {"groupName": "plateEdge", "dofConstraint": 123456}) the following keywords (= default values) may be used:

- **constraintType = "ZeroDisplacement"**
  Type of constraint. Options: "Displacement", "ZeroDisplacement".

- **dofConstraint = 0**
  Component numbers / degrees of freedom that will be constrained (123 - zero translation in all three directions).

- **gridDisplacement = 0.0**
  Value of displacement for components defined in "dofConstraint".

0.6.2 Single Value String

If "Value" is a string, the string value may correspond to an entry in a predefined constraint lookup table. NOT YET IMPLEMENTED!!!!

0.7 FEA Support

Structure for the support tuple = ("Support Name", "Value"). "Support Name" defines the reference name for the support being specified. The "Value" can either be a JSON String dictionary (see Section JSON String Dictionary) or a single string keyword (see Section Single Value String).

0.7.1 JSON String Dictionary

If "Value" is JSON string dictionary the following keywords (= default values) may be used:

0.7.2 Single Value String

If "Value" is a string, the string value may correspond to an entry in a predefined support lookup table. NOT YET IMPLEMENTED!!!!

0.8 FEA Connection

Structure for the connection tuple = ("Connection Name", "Value"). "Connection Name" defines the reference name to the capsConnect being specified and denotes the "source" node for the connection. The "Value" can either be a JSON String dictionary (see Section JSON String Dictionary) or a single string keyword (see Section Single Value String).

0.8.1 JSON String Dictionary

If "Value" is JSON string dictionary the following keywords (= default values) may be used:

0.8.2 Single Value String

If "Value" is a string, the string value may correspond to an entry in a predefined connection lookup table. NOT YET IMPLEMENTED!!!!

0.9 FEA Load

Structure for the load tuple = ("Load Name", "Value"). "Load Name" defines the reference name for the load being specified. The "Value" can either be a JSON String dictionary (see Section JSON String Dictionary) or a single string keyword (see Section Single Value String).

0.9.1 JSON String Dictionary

If "Value" is JSON string dictionary (e.g. "Value" = {"groupName": "plate", "loadType": "Pressure", "pressureForce": 2000000.0}) the following keywords (= default values) may be used:

- **loadType = "(no default)"**
  Type of load. Options: "GridForce", "GridMoment", "LineForce", "LineMoment", "Rotational", "Pressure", "↩ PressureDistribute", "PressureExternal", "Gravity".

- **groupName = "(no default)"**
  Single or list of `capsLoad` names on which to apply the load (e.g. "Name1" or ["Name1","Name2",...]. If not provided, the load tuple name will be used.

- **forceScaleFactor = 0.0**
  Overall scale factor for the force for a "GridForce" load.

- **directionVector = [0.0, 0.0, 0.0]**
  X-, y-, and z- components of the force vector for a "GridForce", "GridMoment", or "Gravity" load.

- **momentScaleFactor = 0.0**
  Overall scale factor for the moment for a "GridMoment" load.

- **gravityAcceleration = 0.0**
  Acceleration value for a "Gravity" load.

- **pressureForce = 0.0**
  Uniform pressure force for a "Pressure" load.

- **pressureDistributeForce = [0.0, 0.0, 0.0, 0.0]**
  Distributed pressure force for a "PressureDistribute" load. The four values correspond to the 4 (quadrilateral elements) or 3 (triangle elements) node locations.

- **angularVelScaleFactor = 0.0**
  An overall scale factor for the angular velocity in revolutions per unit time for a "Rotational" load - applied in a global sense.

- **angularAccScaleFactor = 0.0**
  An overall scale factor for the angular acceleration in revolutions per unit time squared for a "Rotational" load - applied in a global sense.

0.9.2 Single Value String

If "Value" is a string, the string value may correspond to an entry in a predefined load lookup table. NOT YET IMPLEMENTED!!!!

0.10 FEA Analysis

Structure for the analysis tuple = (‘Analysis Name’, ‘Value’). 'Analysis Name' defines the reference name for the analysis being specified. The "Value" can either be a JSON String dictionary (see Section JSON String Dictionary) or a single string keyword (see Section Single Value String).

0.10.1 JSON String Dictionary

If "Value" is JSON string dictionary the following keywords (= default values) may be used:

0.10.2 Single Value String

If "Value" is a string, the string value may correspond to an entry in a predefined analysis lookup table. NOT YET IMPLEMENTED!!!!

0.11 FEA Design Variables

Structure for the design variable tuple = ("DesignVariable Name", "Value"). "DesignVariable Name" defines the reference name for the design variable being specified. This string will be used in the FEA input directly. The "Value" must be a JSON String dictionary (see Section JSON String Dictionary).

0.11.1 JSON String Dictionary

If "Value" is JSON string dictionary the following keywords (= default values) may be used:

0.12 FEA DesignVariableRelation

Structure for the design variable tuple = ("DesignVariableRelation Name", "Value"). "DesignVariableRelation Name" defines the reference name for the design variable being specified. This string will be used in the FEA input directly. The "Value" must be a JSON String dictionary (see Section JSON String Dictionary).

0.12.1 JSON String Dictionary

If "Value" is JSON string dictionary the following keywords (= default values) may be used:

0.13 FEA Design Constraints

Structure for the design constraint tuple = (‘DesignConstraint Name’, ‘Value’). 'DesignConstraint Name' defines the reference name for the design constraint being specified. The "Value" must be a JSON String dictionary (see Section JSON String Dictionary).

0.13.1 JSON String Dictionary

If "Value" is JSON string dictionary the following keywords (= default values) may be used:

0.14 FEA Optimization Control

Structure for the optimization control dictionary = ‘Value’. The "Value" must be a JSON String dictionary (see Section JSON String Dictionary).

0.15 FEA Mass Increments

Structure for the mass increment tuple = (‘MassIncrement Name’, ‘Value’). 'MassIncrement Name' defines the reference name for the mass increment being specified. The "Value" must be a JSON String dictionary (see Section JSON String Dictionary).

0.16 FEA Design Equations

Structure for the design equation tuple = ("DesignEquation Name", ["Value1", ... , "ValueN"]). "DesignEquation Name" defines the reference name for the design equation being specified. This string will be used in the FEA input directly. The values "Value1", ... , "ValueN" are a list of strings containing the equation defintions. (see Section List of equation strings).

0.16.1 List of equation strings

Each design equation tuple value is a list of strings containing the equation definitions

0.17 FEA Table Constants

Structure for the table constant tuple = ("TableConstant Name", "Value"). "TableConstant Name" defines the reference name for the table constant being specified. This string will be used in the FEA input directly. The "Value" is the value of the table constant.

0.18 FEA Design Responses

Structure for the design response tuple = ("DesignResponse Name", "Value"). "DesignResponse Name" defines the reference name for the design response being specified. This string will be used in the FEA input directly. The "Value" must be a JSON String dictionary (see Section JSON String Dictionary).

0.18.1 JSON String Dictionary

If "Value" is JSON string dictionary the following keywords (= default values) may be used:

0.19 FEA Design Equation Responses

Structure for the design equation response tuple = ("DesignEquationResponse Name", "Value"). "DesignEquation↩ Response Name" defines the reference name for the design equation response being specified. This string will be used in the FEA input directly. The "Value" must be a JSON String dictionary (see Section JSON String Dictionary).

0.19.1 JSON String Dictionary

If "Value" is JSON string dictionary the following keywords (= default values) may be used:

0.20 FEA Design Optimization Parameters

Structure for the design optimization parameter tuple = ("DesignOptParam Name", "Value"). "DesignOptParam Name" defines the reference name for the design optimization parameter being specified. This string will be used in the FEA input directly. The "Value" is the value of the design optimization parameter.

0.21 FEA Aerodynamic References

Tuple of the aerodynamic reference input (see Section JSON String Dictionary).

0.21.1 JSON String Dictionary

The following keywords (= default values) may be used: