MSC Nastran Modules

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Based on Presentations from Hanson Chang, Models from Larry Pierce and Investigations from Lutz Peschlow

Agenda

1. Motivation
2. Overview
3. Bulk Data Entries
4. Output Handling
5. Special Topics
6. Summary

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Motivation

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Modular FEM-Approaches

Include Files

- ✓ Store different **components** in different files
- ✓ Includes in Includes
- × Unique **ID ranges** need to be defined for each component
- × Modifications do **not update** along equal components
- × Connections between components need to be defined **manually**

Superelements (SE)

- ✓ SE can be **relocated** via special Bulk Data entries (SEBULK, SELOC, …)
- ✓ Connections can be established **automatically or manually** (SECONCT)
- ✓ ID-ranges between different SE may overlap
- × SE are **reduced** before the assembly run
- × The reduction needs to be **rerun** after modifications

What is missing?

- ➢ Overlapping ID Ranges between components within the assembly
- ➢ Reduction should be optional

MSC Nastran Modules: Overview

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Overview

General Concept

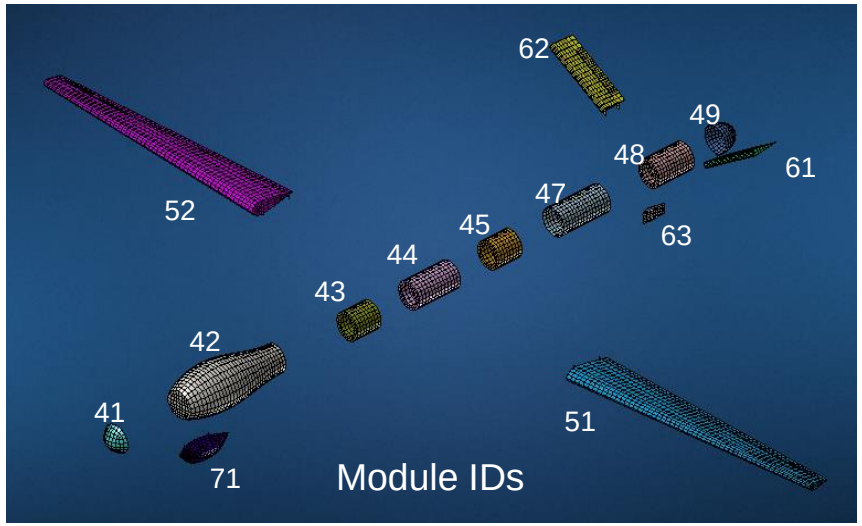
A Module is a runnable **standalone** Bulk Data section that is included in an assembly model

BDF

```
BEGIN BULK
Include ‘empennage.bdf’
Include ‘fuselage.bdf’
Include ‘wings.bdf’
ENDDATA
```

BDF

```
BEGIN BULK
BEGIN MODULE=10 LABEL=EMPEN.
Include ‘empennage.bdf’
END MODULE
BEGIN MODULE=20 LABEL=FUSEL.
Include ‘fuselage.bdf’
END MODULE
BEGIN MODULE=30 LABEL=WING
Include ‘wings.bdf’
END MODULE
ENDDATA
```



IDs must only be unique within a module but not in the whole assembly

Each module must contain all **properties and materials** that are referenced within the module

Only **single level** assemblies are allowed (no module in a module)

Note Use PARAM,CHECKOUT,YES or a free free SOL 103 run to check if a module is free of defects

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Overview

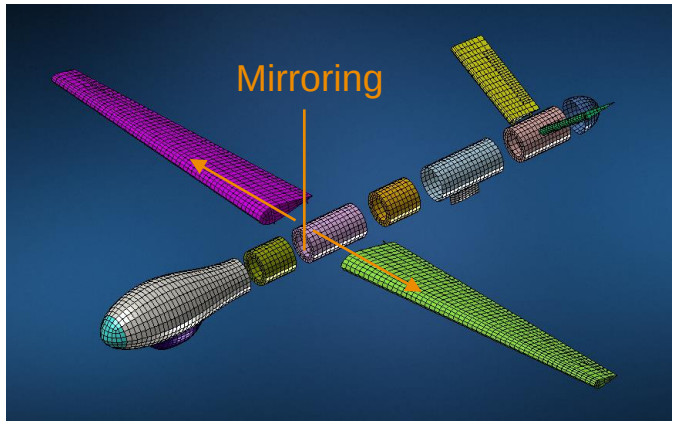
Association and Manipulation

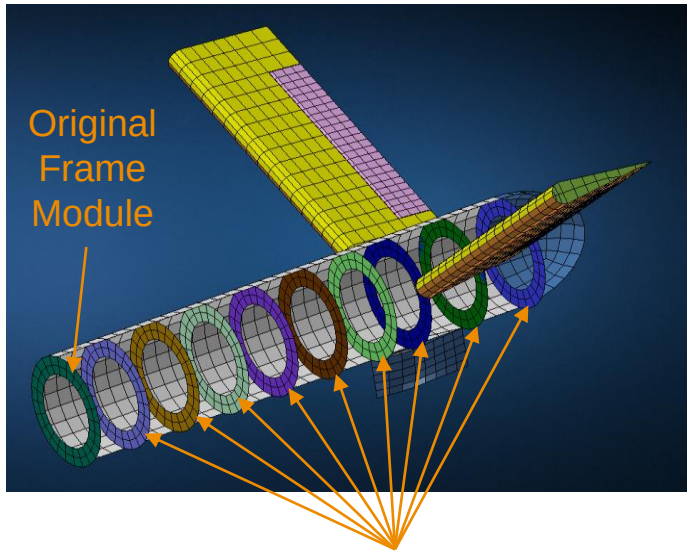
Modules can be **copied**, **mirrored, rotated and translated**

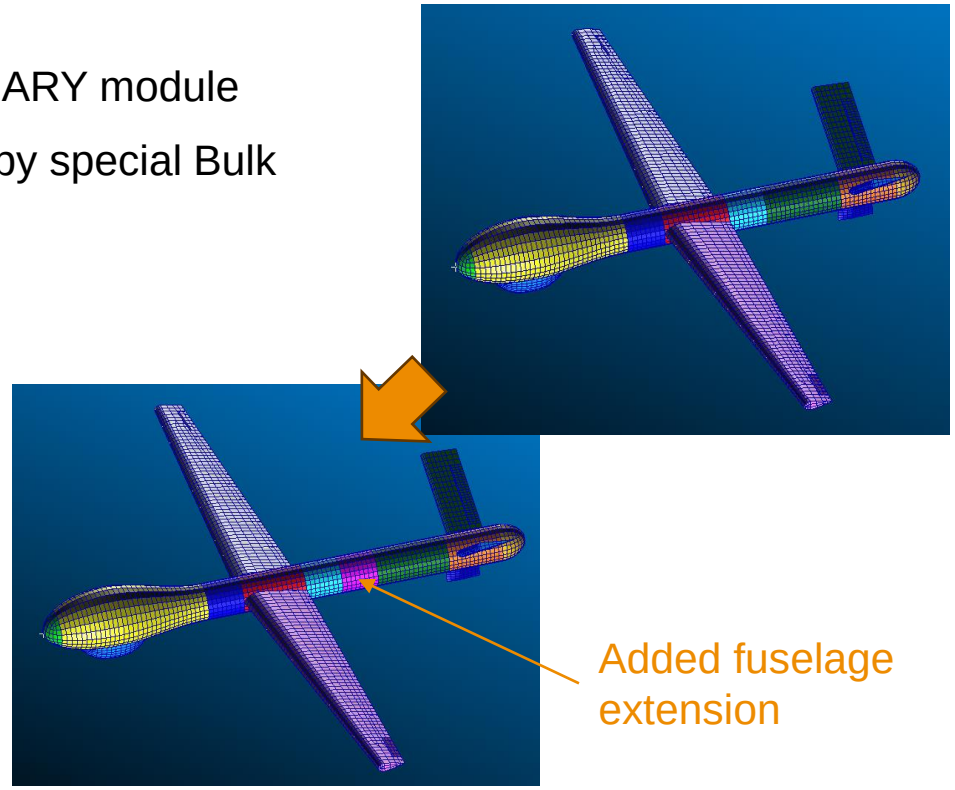
Copied and mirrored modules are called SECONDARY modules

SECONDARY modules always **keep their association** to the original PRIMARY module

Connections between modules can be created automatically, manually, or by special Bulk Data entries including contact







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Overview

Features and Support

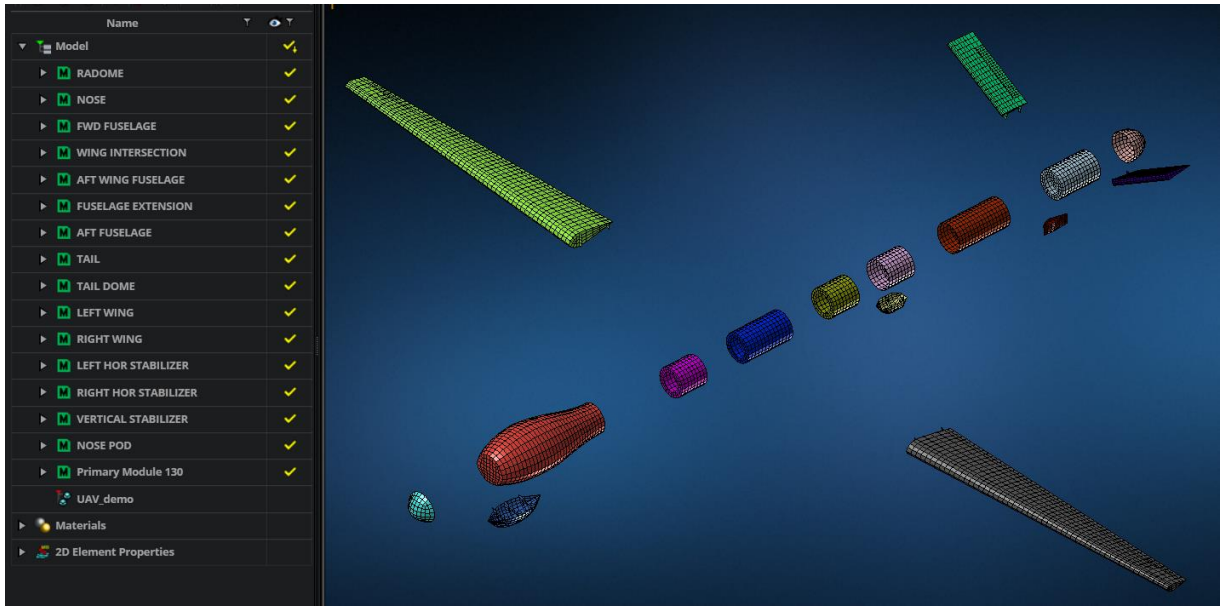
Modules can be reduced to **External Modules** (EXTMDOUT)

Matrices can be added to modules directly (MDDMIG)

Supported Solution Sequences: 101, 103, 105, 107 & 110, 108 & 111, 109 & 112, 400

SOL 200: not supported when optimization or sensitivity analysis is used

Pre/Post: Since 2022.3 MSC Apex supports basic module functionalities



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Bulk Data Entries

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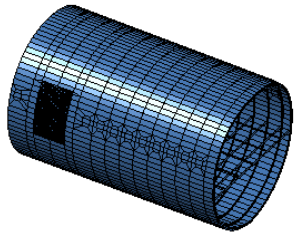
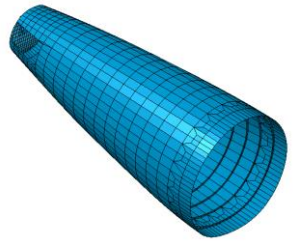
Bulk Data Entries

Handling and Definition

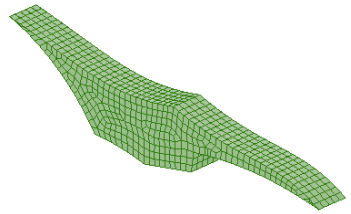
```
Begin MODULE=10
GRID,1,,…
GRID,2,,…
CQUAD4,1,1,…
CQUAD4,2,1,…
PSHELL,1,…
FORCE,1,…
…
END MODULE
```



```
BEGIN MODULE=20
GRID,1,,…
GRID,2,,…
CQUAD4,1,1,…
CQUAD4,2,1,…
PSHELL,1,…
FORCE,1,…
…
END MODULE
```



```
BEGIN MODULE=30
GRID,1,,…
GRID,2,,…
CQUAD4,1,1,…
CQUAD4,2,1,…
PSHELL,1,…
FORCE,1,…
…
END MODULE
```



Module 0

```
BEGIN BULK
GRID,1,…
CBUSH,1,…
MDBULK,ALL,,,AUTO
INCLUDE ‘module10.bdf’
INCLUDE ‘module20.bdf’
INCLUDE ‘module30.bdf’
ENDDATA
```

Note:

- Module 0 entries are optional and may appear anywhere in the bulk between modules
- Cards starting with MD- must be placed in Module 0
- Global Items (PARAMs;GRAV;TEMPD;etc) must be defined in Module 0
- Loads, except inertia Loads, must be defined in the Modules directly

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Bulk Data Entries

Bulk Data Entries Restricted to Module 0 only

Body loading

- ACCEL GRAV RFORCE TEMPD

Load and constraint combination

- LOAD MPCADD SPCADD

Dynamic loading

- ACSRCE DLOAD RLOAD1 RLOAD2 TLOAD1 TLOAD2

Solution control

- EIGB EIGC EIGP EIGR EIGRL FREQ FREQ1 FREQ2 FREQ3 FREQ4 FREQ5 ITER NLPARM NLSTEP TSTEP

Random response

- RANDPS RANDT1 TABRNDG

Damping

- DAMPING HYBDAMP TABDMP1

Model definition

- ACMODL BCPARA MDLPRM SWLDPRM

Miscellaneous

- PARAM
- DMI and DTI
- DEFUSET
- RADBND
- QSET and QSET1
- BCTABL1
- FRFXIT and FRFXIT1

Bulk Data Entries

MDBULK: Module Specification

Defines

- Type of module: Primary (default), Secondary or External
- SECONDARY effectively creates a copy of a PRIMARY
- Connection method: use AUTO for **automatic** connection or MANUAL for **manual** connection in conjunction with a MDCONECT entry

1	2	3	4	5	6	7	8	9	10
MDBULK	MODID	TYPE	RMODID	METHOD	TOL		UNITNO		

```
$.......2.......3.......4.......5.......6.......7.......8.......9
MDBULK   20       REPEAT   10       AUTO     0.05
```

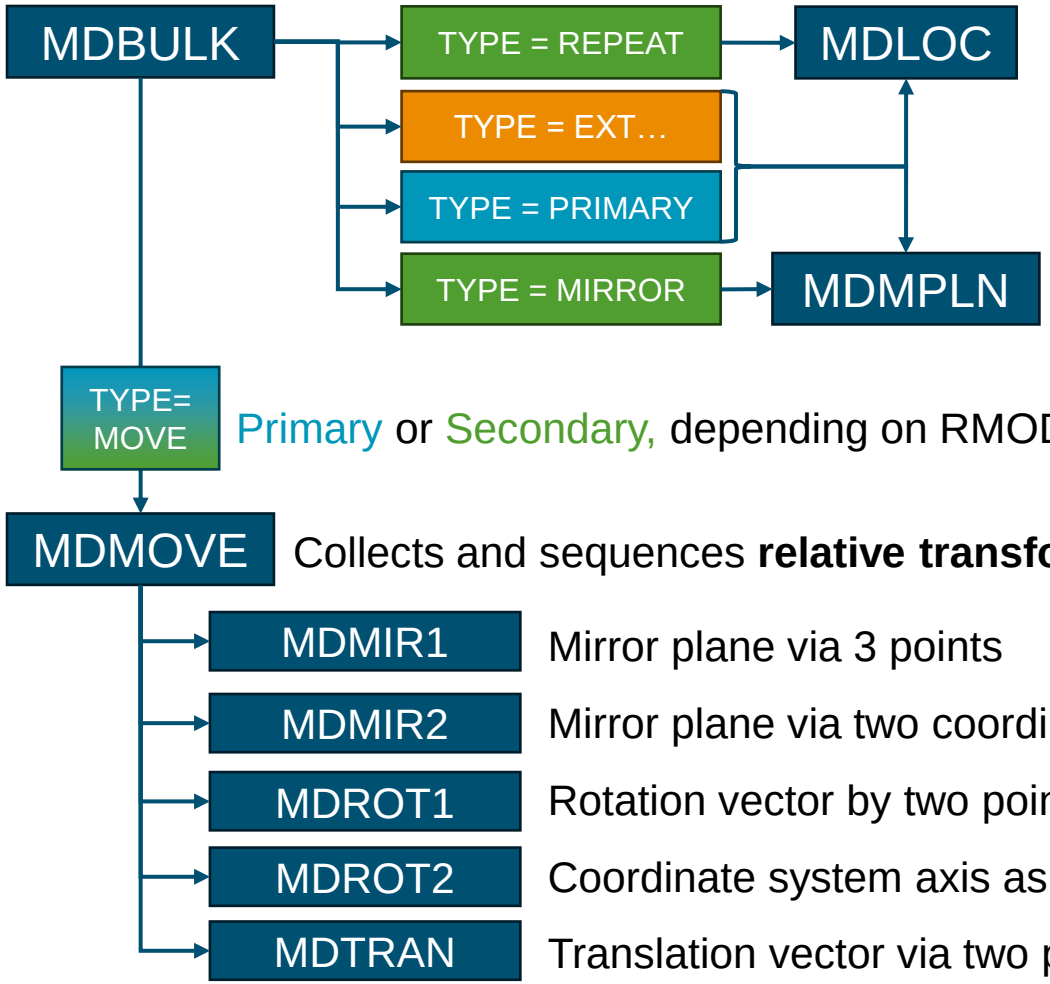
Note

- Modules stay unconnected if MDBULK is not defined
- The automatic connection searches for coincident nodes between different modules within a tolerance (TOL)
- External Modules cannot be mirrored or repeated
- Check the Remarks in the QRG

Describer	Meaning
MODID	Module identification number. (Integer > 0 or Character = "ALL")
TYPE	Module type (Character; default = "PRIMARY")
	PRIMARY — Module with at least one GRID entry in its BEGIN MODULE section.
	REPEAT — Copied Module via reposition or mirroring of a primary Module. See Remarks 9 and 10.
	MIRROR — Copied Module via mirroring of a primary Module. See Remarks 9 and 10.
	MOVE — Copied or primary Module repositioning via MDMOVE entry. See Remarks 8 and 10.
	EXTERNAL — External. See Remarks 11 and 12.
	EXTOP2 — External using an OUTPUT2 file created in an earlier run. See Remarks 11 and 12.
	EXTOP4 — External using an OUTPUT4 file created in an earlier run. See Remarks 11 and 12.
RMODID	Identification number of the reference Module, used only if making a copy; i.e., RMODID>0 and RMODID ≠ MODID and TYPE= "REPEAT", "MIRROR" or "MOVE". (Integer ≥ 0; Default=0). See Remarks 9 and 10.
METHOD	Method to be used when searching for boundary grid points. (Character = "AUTO" or "MANUAL"; Default= "MANUAL")
TOL	Location tolerance to be used when search for boundary grid points. (Real; Default = 1.0e-5)
UNITNO	FORTRAN unit number for the OUTPUT2 or OUTPUT4 file (applicable and meaningful only when TYPE = "EXTOP2" or "EXTOP4"). See Remarks 11 and 12.

Bulk Data Entries

Module Transformation



Position module by selecting three points that coincide with three points in module 0

Mirror module by selecting three points that span a mirror plane in module 0

Primary or Secondary, depending on RMODID

Collects and sequences **relative transformations**

Mirror plane via 3 points

Mirror plane via two coordinate axis

Rotation vector by two points

Coordinate system axis as rotation vector

Translation vector via two points

Note:

- The **listing sequence** in MDMOVE defines the transformation sequence
- MDMIR1/2 must be the **first** Transformation
- Loads and displacements in mirrored Modules are defined in a l**eft-handed coordinate system**
- Mirroring PCOMP, PLOADi and TEMPP1 is currently **not supported**

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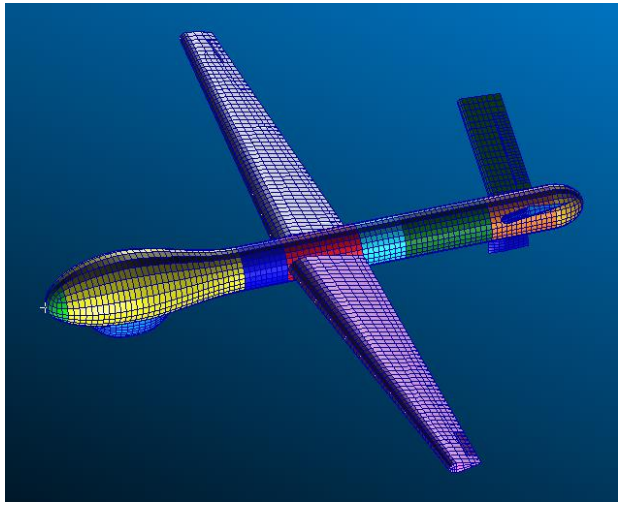
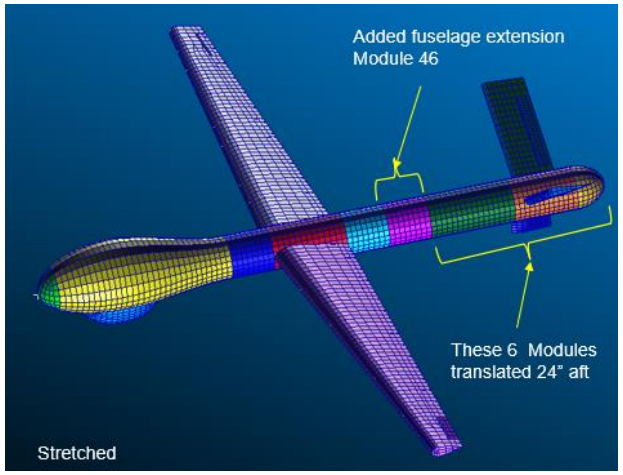
Bulk Data Entries

Transformation Example: Translation






```
Include 'Aft_fuselage.bdf'
$.......2.......3.......4.......5.......6.......7.......8.......9.......X
$ MODULE DEFINITION AND POSITIONING
$ Aft fuselage
MDBULK   47       MOVE     0        auto
MDMOVE   47       200
$ Tail
MDBULK   48       MOVE     0        auto
MDMOVE   48       200
$ Tail dome
MDBULK   49       MOVE     0        auto
MDMOVE   49       200
$ Left hor stabilizer
MDBULK   61       MOVE     0        auto
MDMOVE   61       200
$ Right hor stabilizer
MDBULK   62       MOVE     0        auto
MDMOVE   62       200
$ Vertical stabilizer
MDBULK   63       MOVE     0        auto
MDMOVE   63       200
$ Translation
MDTRAN   200      1        2
POINT    1        0.       0.       0.
POINT    2        24.0     0.       0.
```

Recommendation: Use POINT entries

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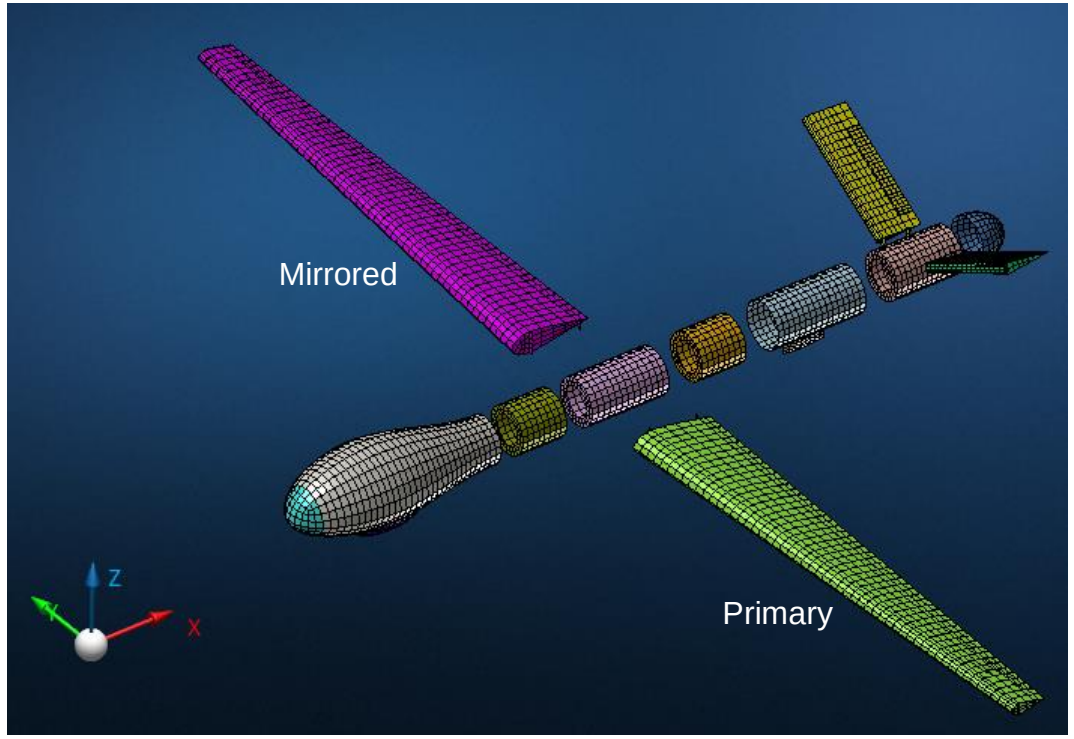
Bulk Data Entries

Transformation Example: Mirroring




```
$ Mirroring the left wing to create new MODULE 9999
$.......2.......3.......4.......5.......6......
MDBULK   9999     MOVE     51       AUTO
MDLABEL  9999     RIGHT WING
MDMOVE   9999     301
MDMIR2   301      0                 xz
```

Alternatively

```
$ Mirroring the left wing to create new MODULE 9999
$.......2.......3.......4.......5.......6......
MDBULK   9999     MOVE     51       AUTO
MDLABEL  9999     RIGHT WING
MDMOVE   9999     301
MDMIR1   301      177      178      999
POINT    177                120.     0.       0.
POINT    178                130.     0.       0.
POINT    999                120.     0.       1.
```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Bulk Data Entries

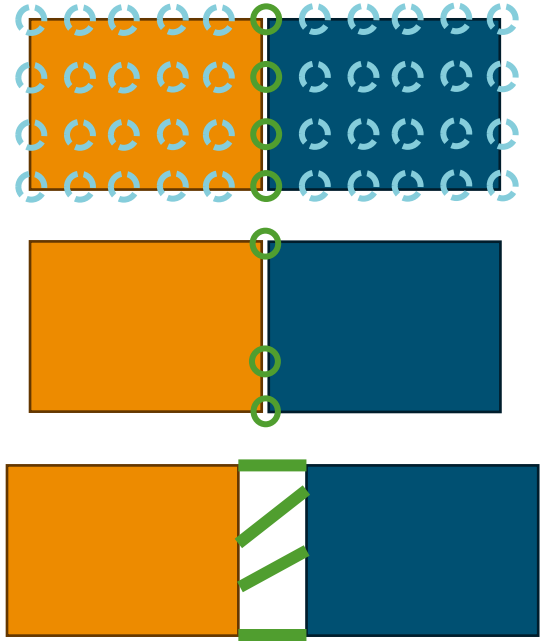
Module Connections

User needs to specify whether modules connect

A. **Automatically**, via node-to-node pairs within a certain tolerance (MDBULK)

B. **Manually** via user defined node-to-node pairs (MDBULK + MDCONCT)

C. **Element-Based** via user defined bulk data entries in module 0 (MDRBE2, MDRBE3, MDBUSH, …)



Bulk Data Entries

MDEXCLD: Exclusion from Automatic Connection

Defines

- A List grids in module A that shall be excluded from the automatic connection with module B

1	2	3	4	5	6	7	8	9	10
MDEXCLD	MIDA	MIDB	GIDA1	GIDA2	GIDA3	GIDA4	GIDA5	GIDA6	
	GIDA7	GIDA8	etc.						

MDBNDRY: Inclusion in Automatic Connection

Defines

- A list of grids in module A that shall be used exclusively for the automatic connection with module B

1	2	3	4	5	6	7	8	9	10
MDBNDRY	MIDA	MIDB	GIDA1	GIDA2	GIDA3	GIDA4	GIDA5	GIDA6	
	GIDA7	GIDA8	etc.						

Note

You may use MDEXCLD and MDBNDRY, when performance degradation for default settings is observed

Bulk Data Entries

MDCONCT: Manual Connection

Defines

- **Manual** grid-to-grid connection between different modules with or without option to modify the boundary grid location to enforce coincidence

Note

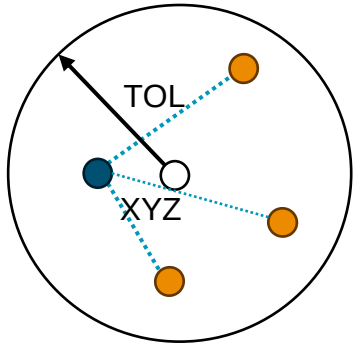
- The connection is based on rigid elements (RBE2)
- There are two formats: search at a location XYZ within a tolerance TOL for grids and connect these / select a grid and connect it to others

1	2	3	4	5	6	7	8	9	10
MDCONCT	BID	TYPE	TOL	X	Y	Z		CID	
	MID1	GID1	MID2	GID2	MID3	GID3	MID4	GID4	
	MID5	GID5	etc.						

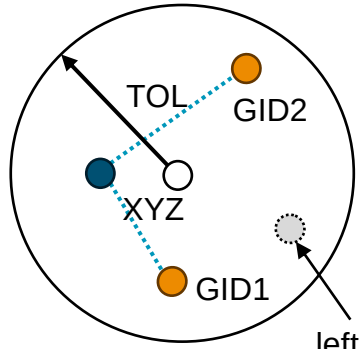
Alternate Format:

1	2	3	4	5	6	7	8	9	10
MDCONCT	BID	TYPE	TOL	GRID			MODID		
	MID1	GID1	MID2	GID2	MID3	GID3	MID4	GID4	
	MID5	GID5	etc.						

Describer	Meaning
BID	Unique Boundary identification number. (Integer > 0)
TYPE	Connection Option. (Character: "MERGE", "RIGID", "RRBE2", "MRBE2" or Blank, Default="MRBE2".
TOL	Location tolerance to be used when searching or checking for boundary grid points. (Real; Default=1.0e-5)
X,Y,Z	Connection (Search) location. (Real, Default=0.0)
GRID	Grid Identification for Connection (Search). (Integer > 0) See Remark 13.
MODID	Identification number of Module containing GRID. (Integer ≥ 0, Default=0)
CID	Coordinate System in Module 0 to be applied to XYZ location. (Integer ≥ 0, Default=0)
MIDi	Module Identification number for grid/scalar reference. (Integer ≥ 0)
GIDi	Identification number of a grid or scalar point in the reference module MIDi, which will be verified to be in TOL of the Location. (Integer ≥ 0)



No GIDi specified



GIDi specified

If GRID is specified, then XYZ = GRID

GRID or closest to XYZ in MDCONECT-Module is Independent

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Bulk Data Entries

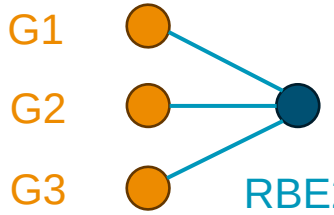
MDCONCT: Manual Connection

TYPE = MERGE

Grids are moved to enforce coincidence

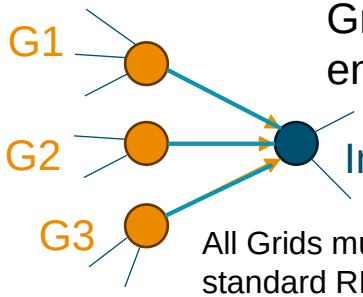
Independent

TYPE = RIGID (used for the automatic connection)



Independent

TYPE = MRBE2 (default)

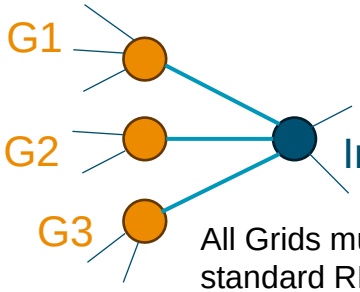


Grids are moved to enforce coincidence

Independent

All Grids must be independent Grids of standard RBE2 within a module

TYPE = RRBE2



Independent

All Grids must be independent Grids of standard RBE2 within a module

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Bulk Data Entries

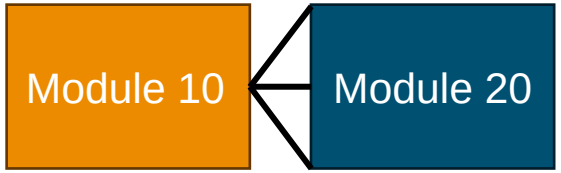
Element-Based Rigid and Flexible Connections Between Modules

CWELD, CFAST, CSEAM and DMIG equivalents

MDWELD, MDFAST, MDSEAM, MDDMIG, MDBUSH (2023.2)

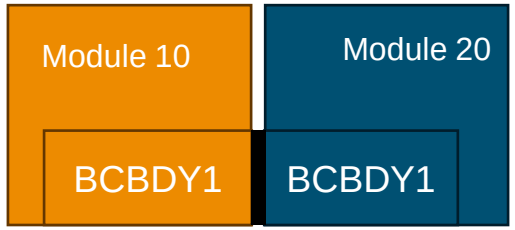
BOLT, MPC, RBE2, RBE3, RJOINT, and RROD equivalents

MDBOLT, MDMPC, MDRBE2, MDRBE3, MDRJNT, MDRROD



Contact between bodies in different Modules based on BCONECT and BCTABL1 entries

MDBCNCT, MDBCTB1



Note

- Contact between bodies of the **same module** should be defined within the module via BCONECT and BCTABL1
- **Fluid-Structure** coupling between different modules was introduced in 2021.4 (MDFSET and MDSSET)

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Output Handling

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Output Handling

F06 file

```
     M O D E L   S U M M A R Y          MODULE = 0
ENTRY NAME        NUMBER OF ENTRIES
----------        -----------------
    HDF5DA                       1
   HDF5OUT                       1
    MDBULK                       8
   MDLABEL                      16
    MDMIR2                       1
    MDMOVE                       7
    MDTRAN                       1
     PARAM                       3
     POINT                       5
    UDNAME                       4

     M O D E L   S U M M A R Y          MODULE = 41
ENTRY NAME        NUMBER OF ENTRIES
----------        -----------------
     CBEAM                      60
    CQUAD4                      84
      GRID                      97
      MAT1                       1
    PBEAML                       6
    PSHELL                       1

     M O D E L   S U M M A R Y          MODULE = 42
ENTRY NAME        NUMBER OF ENTRIES
----------        -----------------
     CBEAM                     384
    CQUAD4                    1164
      CROD                     360
      GRID                    1177
      MAT1                       1
    PBEAML                      12
      PROD                      15
    PSHELL                       9
```

```
0                MODULE DEFINITION TABLE (SORTED BY MODULE ID)
0                PRIMARY
   MODULE        MODULE                TYPE                              LABEL
  --------      --------    ------------------------------  ------------------------------------------------
         0             0    MAIN BULK DATA
        41             0    PRIMARY (BEGIN MODULE)          RADOME
        42             0    PRIMARY (BEGIN MODULE)          NOSE
        43             0    PRIMARY (BEGIN MODULE)          FWD FUSELAGE
        44             0    PRIMARY (BEGIN MODULE)          WING INTERSECTION
        45             0    PRIMARY (BEGIN MODULE)          AFT WING FUSELAGE
        46             0    PRIMARY (BEGIN MODULE)          FUSELAGE EXTENSION
        47            47    PRIMARY (BEGIN MODULE)          AFT FUSELAGE
        48            48    PRIMARY (BEGIN MODULE)          TAIL
        49            49    PRIMARY (BEGIN MODULE)          TAIL DOME
        51 original    0    PRIMARY (BEGIN MODULE)          LEFT WING
        61            61    PRIMARY (BEGIN MODULE)          LEFT HOR STABILIZER
        62            62    PRIMARY (BEGIN MODULE)          RIGHT HOR STABILIZER
        63            63    PRIMARY (BEGIN MODULE)          VERTICAL STABILIZER
        71             0    PRIMARY (BEGIN MODULE)          NOSE POD
       130             0    PRIMARY (BEGIN MODULE)          BELLY PAD
      9999 copy 51          COPY (MDBULK)                   RIGHT WING
```


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Output Handling

F06 file

Independent and dependent DOF for MPC connections

```
                    MDCONCT (MANUAL & AUTOMATIC) CONNECTION SUMMARY BY MODULE AND INDEPENDENT POINT ID
                                 INDEPENDENT                DEPENDENT
   MDCONCT ID    TYPE            POINT( MODULE )            POINT( MODULE )            POINT( MODULE )            POINT( MODULE )            POINT( MODULE )

       10001     RIGID          1001M (       0)           109M (      10)           203M (      20)           307M (      30)           401M (      40)

       10002     RIGID           103M (      10)           301M (      30)

       10003     RIGID           106M (      10)           304M (      30)

       10009     RIGID           308M (      30)           402M (      40)

       10010     RIGID           309M (      30)           403M (      40)


                                                  AUTOMATIC CONNECTION SUMMARY BY INTERNAL RIGID ID
    INTERNAL                     INDEPENDENT                DEPENDENT
    RIGID ID      TYPE           POINT( MODULE )            POINT( MODULE )            POINT( MODULE )            POINT( MODULE )            POINT( MODULE )

  9000000001      RIGID           107A (      10)           201A (      20)

  9000000002      RIGID           209A (      20)           407A (      40)
```

Manual connections

PARAM,SEMAPPRT,-1 suppresses the printout

Automatic connections

M and A after point ID indicates **Manual or Automatic** connection

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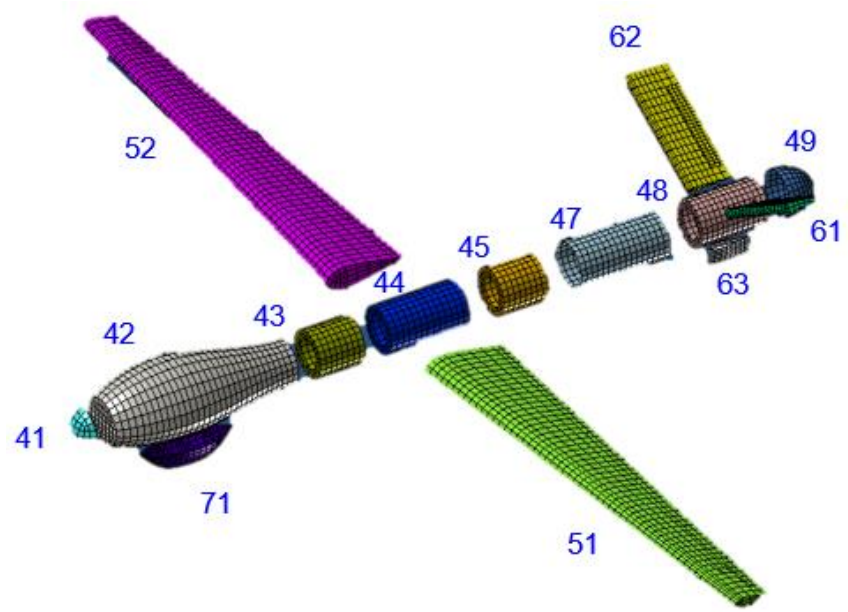
Output Handling

HDF5DA (Case, 2023.2)

Per Default, a single HDF5 output file is created, that contains all modules
A Case Control command HDFDA=-1 (Default 0) creates a dedicated output HDF5 file for each module



uav_base_0.h5
uav_base_41.h5
uav_base_42.h5
uav_base_43.h5
uav_base_44.h5
uav_base_45.h5
uav_base_47.h5
uav_base_48.h5
uav_base_49.h5
uav_base_51.h5
uav_base_52.h5
uav_base_61.h5
uav_base_62.h5
uav_base_63.h5
uav_base_71.h5

Filename-Logic:
Jobname_ModuleID.h5

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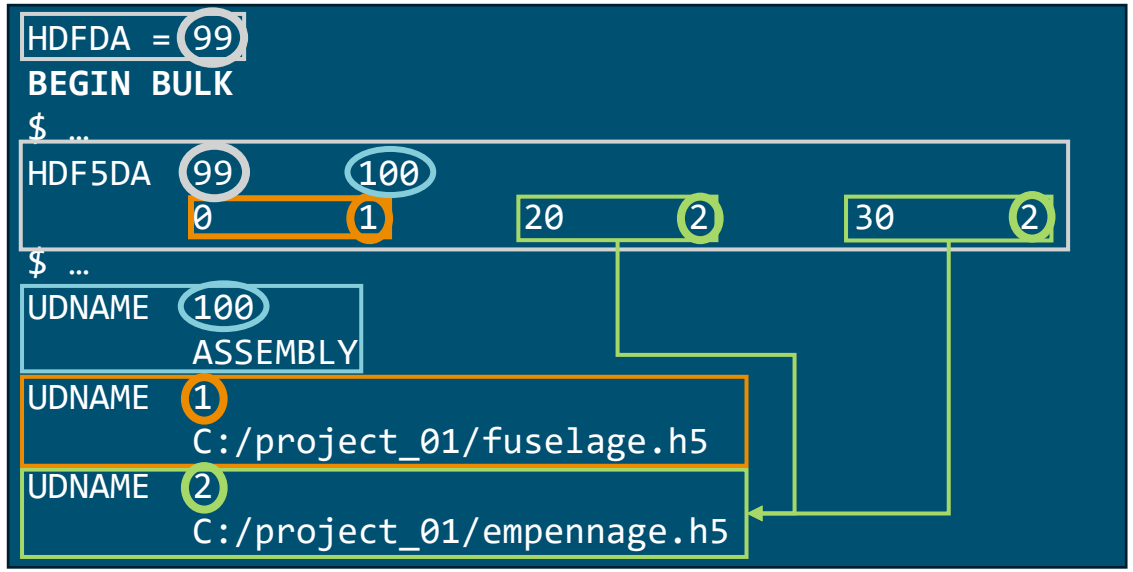
Output Handling

HDF5DA & H5OUT (Bulk, 2024.1)

Since 2024.1 case control command HDFDA > 0 can be used to point to a HDFDA bulk data entry. This entry can be used to specify the filenames and to summarize modules in different HDF5 files.

1	2	3	4	5	6	7	8	9	10
HDF5DA	ID	CONFIG							
	MDID0	UDID0	MDID1	UDID1	MDID2	UDID2	MDID3	UDID3	
	MDID4	UDID4	MDID5	UDID5	-etc.-				

Example



Note:

- HDF5DA only works with the HDF5OUT entry, but not with MDLPRM,HDF5,i.
- The Bulk Data Entry H5OUT can be used to override HDF5OUT Settings for a specific module. Parameters for H5OUT and HDF5OUT are identical.
- NLOPRM OUTCTRL=INTERM is not supported

1	2	3	4	5	6	7	8	9	10
H5OUT	MDID								
	PARAM1	VAL1	PARAM2	VAL2	-etc.-	-etc.-			

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Output Handling

MDSET (2024.1)

Equivalent of Case Control Sets but for Modules

MDSET 1 = module-ID/entity-ID

Examples:

MDSET 1 = 14/2 15/3 16/7 THRU 100
MDSET 1 = 14/2 15/3 7 79 17/12 45

If module-ID is not specified, entities of every module are used
MDSET 1 = 1 4 16 $Collects Entities 1 4 and 16 of every module

If ALL is specified for Entity, all entities of a module are used
MDSET 2 = 14/ALL

MDSET may be referenced by these commands only:

DISP	MAXMIN	PACCELERATION
SPCF	GPKE	
FORCE	MPRESS	
STRAIN	EKE	
MPCF	EDE	
STRESS	VELOCITY	
ESE	ACCELERATION	
GPFORCE	SDISPLACEMENT	
NLLOAD	SVELOCITY	
NLSTRESS	SACCELERATION	
OLOAD	SVECTOR	

Output Handling

MDSET (2024.1)

```
SPIDER MODEL                                                    JUNE  26, 2024  MSC Nastran  5/13/24   PAGE    10
                                                                                    MODULE 0          ,
                                                                                    SUBCASE 1

                                D I S P L A C E M E N T   V E C T O R

  POINT ID.   TYPE          T1             T2             T3             R1             R2             R3
         1      G      1.959730E-02   3.083406E-02  -2.972966E-02   0.0            0.0            0.0
         2      G      1.909738E-02   1.960083E-02  -2.524131E-03   0.0            0.0            0.0
         3      G     -2.561287E-02   3.007953E-02   6.470472E-04   0.0            0.0            0.0
         4      G     -2.819896E-02   2.315934E-02  -7.786111E-04   0.0            0.0            0.0
         5      G      1.602221E-01   7.747936E-02   4.923393E-02   0.0            0.0            0.0
         6      G      4.361359E-02   1.484131E-02   2.136019E-02   0.0            0.0            0.0
         7      G      3.466638E-02   1.567521E-02   1.011420E-02   0.0            0.0            0.0
        10      G      3.004734E-02   1.119287E-02   9.962229E-03   0.0            0.0            0.0
SPIDER MODEL                                                    JUNE  26, 2024  MSC Nastran  5/13/24   PAGE    11
                                                  CENTERMODULE-1                    MODULE 10         ,
                                                                                    SUBCASE 1

                                D I S P L A C E M E N T   V E C T O R

  POINT ID.   TYPE          T1             T2             T3             R1             R2             R3
      9184      G      7.152857E-02   1.303083E-02   5.000511E-02   0.0            0.0            0.0
      9219      G      6.713610E-02   1.831799E-02   3.824472E-02   0.0            0.0            0.0
      9241      G      6.069882E-02   1.230576E-02   4.030243E-02   0.0            0.0            0.0
      9280      G      6.681939E-02   1.835889E-02   3.811188E-02   0.0            0.0            0.0
SPIDER MODEL                                                    JUNE  26, 2024  MSC Nastran  5/13/24   PAGE    12
```


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Special Topics

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External Modules (2022.2)

All solution sequences which support modules support external modules

Creation Run

- Replace EXTSEOUT with **EXTMDOUT** Case Control command
- QSET and SPOINTS need to be placed in MODULE 0

Assembly Run

- Two-step approach recovery only
- MDBULK is used to further specify the external Modules

Note

- External Modules can be relocated/mirrored by MDLOC/MDMPLN but not copied

Not Supported

- Combination with external Superelements
- Load Selection in assembly run
- Rotors and Fluid elements

EXTMDOUT External Module Creation Specification

Request the creation of an external module in SOLs 101, 103, 107 through 112, or 400 only.

Format:

EXTMDOUT [(STIFFNESS MASS DAMPING K4DAMP LOADS,

ASMBULK [= { MAN / AUTO }] , EXTBULK , EXTID = *mdid*,

DMIGSFIX = { *cccccc* / EXTID } { MATDB (or MATRIXDB)[= *dbext*] / DMIGDB[= *dbext*] / DMIGOP2 = *unitop2* / DMIGPCH / MATOP4 (or MATRIXOP4) = *unitop4* }))]

Further information:
https://simcompanion.hexagon.com/customers/s/article/SimAcademy-Webinar-External-Modules-in-MSC-Nastran & RG 2022.2

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Rotordynamics

Guidelines and Limitations

- CAMPBLL, DDVAL, RGYRO, ROTHYBD, ROTOR, ROTORG, RSPINR, RSPINT, UNBALNC entries may be specified in a Module.
- ROTHYBD may be specified in a Module and may reference a HYBDAMP entry. But the HYBDAMP entry must be specified in Module 0.
- A rotor cannot span multiple modules
- SOL 128 (Nonlinear Frequency Response) is currently not Supported

Miscellanous

Acoustics

- A fluid can be placed in a separate module
- The connection via ACMODL stays as is

Adams Modal Neutral File (MNF)

- ADAMSMNF case control command is supported in conjunction with modules
- ASET-Points in Module 0, could be connected with module internal nodes

Summary and Discussion

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Summary & Discussion

Pros and Cons

Non-Unique IDs between different components
- ➢ Simplified communication between departments and suppliers

Transformation techniques
- ➢ Faster generation of variants

Primary-Secondary **association**
- ➢ Speed up changes in repeating components

Dedicated **input and output**
- ➢ Reduces Data transfer and simplifies communication

Pre- and Postprocessing is not fully supported yet
- ➢ Scripting and Customization is necessary

Relatively **new technique**
- ➢ Experience and best practices must be developed

Additional **definitions and entries** are needed
- ➢ Increased head off for small models, that are not used in assemblies

<u>Recommendations</u>
- The benefit of modules increases when analyzing assemblies with many repeating components
- Incorporate Modules step by step into existing assemblies for a soft transition

Thank You

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