

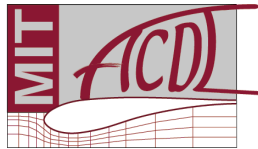


EGADS: Engineering Geometry Aircraft Design System

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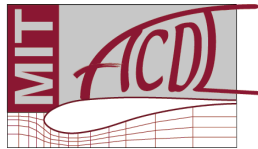


Revision 1.06 -- December 2014

Outline



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 - Geometry
 - Topology
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- **API**
 - Utility & IO Functions
 - Attribution
 - Geometry
 - Topology
 - Tessellation
 - High-Level Functions

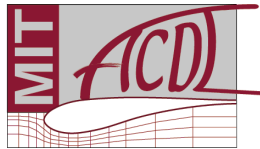


Overview



Provide a “bottom up” and/or Constructive Solid Geometry foundation for building Aircraft

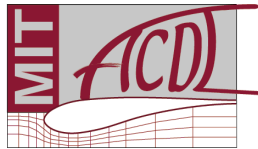
- **Built upon OpenCASCADE**
 - Open Source solid modeling geometry kernel
 - Support for manifold and non-manifold data
 - Reading & writing IGES, STEP and native formats
 - C++ with ~17,000 methods!
- **Open Source (LGPL v2.1)**
- **C/C++ and FORTRAN Interfaces**
 - Single API with minor variations for FORTRAN
 - Always returns an integer code (success/error condition)
 - Requires C pointer access in FORTRAN
 - Cray-pointer construct
 - C-pointers (2003 extension to FORTRAN 90)
 - Both supported by Intel FORTRAN and **gfortran**
 - API contains memory functions



Overview



- **System Support (32 & 64 bit):**
 - **Mac OSX** with **gcc**, **ifort** and/or **gfortran**
 - **LINUX** with **gcc**, **ifort** and/or **gfortran**
 - **Windows** with Microsoft Visual Studio C++ and **ifort**
 - Compiler version must match system used to build OpenCASCADE
 - No globals (but not thread-safe due to OpenCASCADE)
 - Various levels of output (0-none, through 3-debug)
 - Written in C and C++
- **EGADS Objects**
 - Treated as “blind” pointers -- an ego
 - Can access internals in C/C++
 - Egos are INTEGER*8 variables in FORTRAN
 - Allows for same source code regardless of size of pointer
 - Requires “freeing” of internal lists of objects (not in C/C++)



Objects

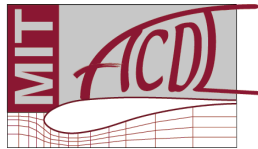


- **C Structure Definition:**

```
typedef struct egObject {  
    int    magicnumber;      /* must be set to validate the object */  
    short  oclass;          /* object class */  
    short  mtype;           /* object member type */  
    void   *attrs;          /* attributes or reference */  
    void   *blind;          /* blind pointer to OCC or EGADS data */  
    struct egObject *topObj; /* top of the hierarchy or context (if top) */  
    struct egObject *ref;    /* threaded list of references */  
    struct egObject *prev;   /* back pointer */  
    struct egObject *next;   /* forward pointer */  
} egObject;  
#define ego egObject*;
```

- **Context Object**

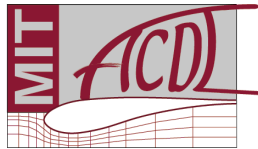
- Holds 'globals' including output level
- Start of dual-threaded list of active egos
- Pool of deleted objects



Objects -- Attribution



- **Attributes**
 - Are identified by a **name** (character string with no spaces or other special characters)
 - Each named attribute has a single **type**:
 - Integer
 - Real (double precision)
 - String (can have spaces and other special characters)
 - And a **length** (for Integer and Real types)
- **Objects**
 - Any Object (except for REFERENCE) may have multiple Attributes
 - Only Attributes on Topological Objects are **copied**
 - Only Attributes on Topological Objects are **persistent** -- and this is available only for “.egads” file IO.
- **SBOs and Intersection Functions**
 - Attributes on Faces will be carried through to the resultant fragments after intersections

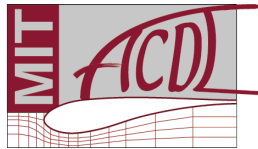


Objects -- Attribution



- **Some operations return more complete associations**
 - Attributes on Faces are always copied from the source regardless of the Function* (an exact copy, trimmed or split)
 - These return a list of Face mappings for each Face in the result:
 - `EG_filletBody`
 - `EG_chamferBody`
 - `EG_hollowBody`
 - The list contains an operation and an index to the source object:

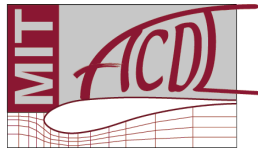
<u>Operation</u>	
NODEOFF (1)	The Face is the result of a Node – the index is that of the Node in the source Body
EDGEOFF (2)	The Face is the result of an Edge – the index is the Edge index (see <code>EG_indexBodyTopo</code>)
FACEDUP* (3)	The Face is an exact copy of the source
FACECUT* (4)	The Face has been trimmed or split from the source
FACEOFF (5)	The Face is offset from the source Face



Objects -- Geometry



- **PCURVE -- Parameter Curves**
 - 2D Curves in the Parametric space $[u,v]$ of a Surface
 - Single “running” parameter t
 - $[u,v] = f(t)$
- **CURVE**
 - 3D Curves
 - Single “running” parameter t
 - $[x,y,z] = f(t)$
- **SURFACE**
 - 3D Surfaces of 2 parameters $[u,v]$
 - $[x,y,z] = f(u,v)$



Objects -- PCURVE/CURVE



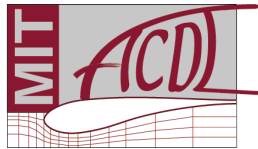
- **LINE**

	<u>Curve (6)</u>	<u>PCurve (4)</u>
Location	$[x,y,z]$	$[u,v]$
Direction	$[dx,dy,dz]$	$[du,dv]$

- **CIRCLE**

	<u>Curve (10)</u>	<u>PCurve (7)</u>
Center	$[x,y,z]$	$[u,v]$
Xaxis	$[dx1,dx2,dx3]$	$[dx1,dx2]$
Yaxis	$[dy1,dy2,dy3]$	$[dy1,dy2]$
Radius		

note: **Xaxis** and **Yaxis** should be orthogonal



Objects -- PCURVE/CURVE



- **ELLIPSE**

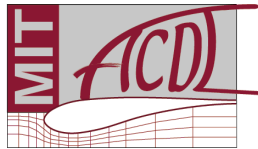
	<u>Curve (11)</u>	<u>PCurve (8)</u>
Location	$[x,y,z]$	$[u,v]$
Xaxis	$[dx1,dx2,dx3]$	$[dx1,dx2]$
Yaxis	$[dy1,dy2,dy3]$	$[dy1,dy2]$
MajorRadius		
MinorRadius		

note: **Xaxis** and **Yaxis** should be orthogonal

- **PARABOLA**

	<u>Curve (10)</u>	<u>PCurve (7)</u>
Location	$[x,y,z]$	$[u,v]$
Xaxis	$[dx1,dx2,dx3]$	$[dx1,dx2]$
Yaxis	$[dy1,dy2,dy3]$	$[dy1,dy2]$
Focus		

note: **Xaxis** and **Yaxis** should be orthogonal



Objects -- *PCURVE/CURVE*



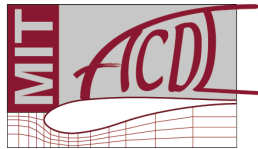
- **HYPERBOLA**

	<u>Curve (11)</u>	<u>PCurve (8)</u>
Location	$[x,y,z]$	$[u,v]$
Xaxis	$[dx1,dx2,dx3]$	$[dx1,dx2]$
Yaxis	$[dy1,dy2,dy3]$	$[dy1,dy2]$
MajorRadius		
MinorRadius		

note: **Xaxis** and **Yaxis** should be orthogonal

- **TRIMMED** (has Reference Geometry)
 - 2 in length for both Curve types (**t-start** & **t-end**)
- **OFFSET** (has Reference Geometry)

	<u>Curve (4)</u>	<u>PCurve (1)</u>
Direction	$[dx,dy,dz]$	-
Offset		



Objects -- PCURVE/CURVE

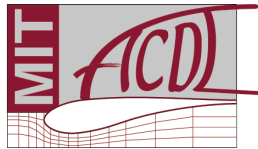


- **BEZIER** (3 integer header):

BitFlag	2 - rational, 4 - periodic	
Degree		
nCP		
	<u>Curve</u>	<u>PCurve</u>
ControlPts	$3*nCP$	$2*nCP$
Weights	nCP	nCP
note: Weights only if rational		

- **BSPLINE** (4 integer header):

BitFlag	2 - rational, 4 - periodic	
Degree		
nCP		
nKnots		
	<u>Curve</u>	<u>PCurve</u>
Knots	$nKnots$	$nKnots$
ControlPts	$3*nCP$	$2*nCP$
Weights	nCP	nCP
note: Weights only if rational		



Objects -- ***SURFACE***



- **PLANE** (9 doubles in length):

Location $[x,y,z]$

Xaxis $[dx1,dx2,dx3]$

Yaxis $[dy1,dy2,dy3]$

note: **Xaxis** and **Yaxis** should be orthogonal

- **SPHERICAL** (10 doubles in length):

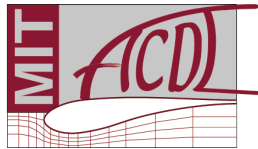
Center $[x,y,z]$

Xaxis $[dx1,dx2,dx3]$

Yaxis $[dy1,dy2,dy3]$

Radius

note: **Xaxis** and **Yaxis** should be orthogonal



Objects -- SURFACE



- **CONICAL** (14 doubles in length):

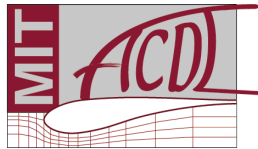
Location	$[x,y,z]$
Xaxis	$[dx1,dx2,dx3]$
Yaxis	$[dy1,dy2,dy3]$
Direction	$[dz1,dz2,dz3]$ rotation axis (<i>may be LeftH</i>)
Angle	
Radius	

note: **Xaxis**, **Yaxis** and **Direction** should be orthogonal

- **CYLINDRICAL** (13 doubles in length):

Center	$[x,y,z]$
Xaxis	$[dx1,dx2,dx3]$
Yaxis	$[dy1,dy2,dy3]$
Direction	$[dz1,dz2,dz3]$ rotation axis (<i>may be LeftH</i>)
Radius	

note: **Xaxis** and **Yaxis** should be orthogonal



Objects -- SURFACE



- **TOROIDAL** (14 doubles in length):

Location $[x,y,z]$
Xaxis $[dx1,dx2,dx3]$
Yaxis $[dy1,dy2,dy3]$
Direction $[dz1,dz2,dz3]$ rotation axis (*may be LeftH*)
MajorRadius
MinorRadius

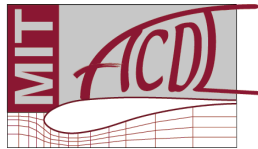
note: **Xaxis**, **Yaxis** and **Direction** should be orthogonal

- **REVOLUTION** (6 doubles in length):

Center $[x,y,z]$
Direction $[dx,dy,dz]$

- **EXTRUSION** (3 doubles in length):

Direction $[dx,dy,dz]$



Objects -- *SURFACE*



- **BEZIER** (5 integer header):

BitFlag 2 - rational, 4 - uPeriodic, 8 - vPeriodic
uDegree
nCPu
vDegree
nCPv

Data Packed:

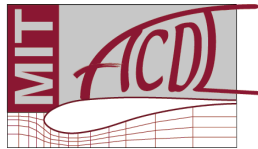
ControlPts $3 * nCPu * nCPv$
Weights $nCPu * nCPv$
note: **Weights** only if rational

- **TRIMMED** (has Reference Geometry)

- 4 in length (**u-start**, **u-end**, **v-start** & **v-end**)

- **OFFSET** (has Reference Geometry)

- 1 in length -- **offset distance**



Objects -- SURFACE



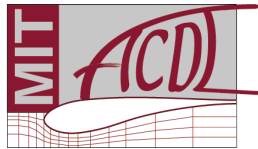
- **BSPLINE** (7 integer header):

BitFlag 2 - rational, 4 - uPeriodic, 8 - vPeriodic
uDegree
nCPu
nUKnots
vDegree
nCPv
nVKnots

Data Packed:

uKnots *nUKnots*
vKnots *nVKnots*
ControlPts $3*nCPu*nCPv$
Weights $nCPu*nCPv$

note: **Weights** only if rational

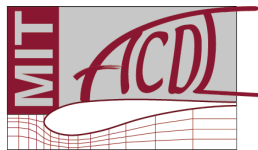


Objects -- Topology



<u>EGADS Topological Entity</u>	<u>OpenCASCADE term</u>	<u>Geometric Entities</u>
Model	Compound Shape	
Body	Solid (or lesser shape)	
Shell		
Face		surface
Loop	Wire	* see note below
Edge		curve
Node	Vertex	

- Topological entities have children (entities lower on the table) except for **Nodes**
- * **Loops** may be geometry free or have associated **PCurves** (one for each **Edge**) and the **surface** where the **PCurves** reside



Objects -- Topology

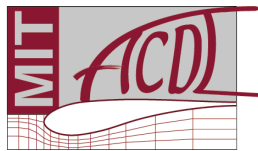


- **NODE**

- Contains $[x,y,z]$

- **EDGE**

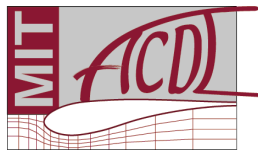
- Has a 3D **CURVE** (if not **DEGENERATE**)
- Has a t range (t_{min} to t_{max} , where $t_{min} < t_{max}$)
- The positive orientation is going from t_{min} to t_{max}
- Has a **NODE** for t_{min} and for t_{max}
- Can be **ONENODE** (closed or periodic), **TWONODE**, or **DEGENERATE** (which has a single **NODE** and a valid range which will be used for the associated **PCurve**)



Objects -- Topology



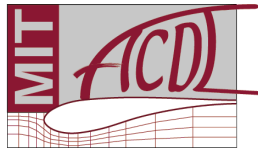
- **LOOP** (without a reference **SURFACE**)
 - Free standing collection of **EDGES** that can be used in a non-manifold setting (for example in WireBodies)
 - Collections of **EDGES** associated with a **PLANE** which does not require **PCurves** in OpenCASCADE
 - An ordered collection of **EDGE** objects with associated senses that define the connected Wire
 - Segregates space by maintaining *material* to the left of the running **LOOP** (or traversed right-handed pointing out of the intended volume)
 - No **EDGES** should be **DEGENERATE**
 - Can be **OPEN** or **CLOSED** (comes back on itself)



Objects -- Topology



- **LOOP** (with a reference **SURFACE**)
 - Collections of **EDGES** (like without a **SURFACE**) followed by a corresponding collection of **PCurves** that define the $[u,v]$ trimming on the **SURFACE**
 - **DEGENERATE EDGES** are required when the $[u,v]$ mapping collapses like at the apex of a cone (note that the **PCurve** is needed to be fully defined using the **EDGE's** t range)
 - An **EDGE** may be found in a **LOOP** twice (with opposite senses) and with different **PCurves**. For example a closed cylindrical surface at the seam -- one **PCurve** would represent the beginning of the period where the other is the end of the periodic range.

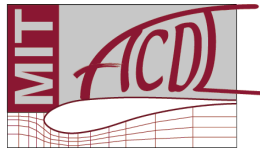


Objects -- Topology



- **FACE**

- A **SURFACE** bounded by one or more **LOOPs** with associated senses
- Only one outer **LOOP** (sense = 1) and any number of inner **LOOPs** (sense = -1). Note that under very rare conditions a **LOOP** may be found in more than 1 **FACE** -- in this case the one marked with sense = +/- 2 must be used in a reverse manner.
- All **LOOPs** must be **CLOSED**
- If the **SURFACE** is a **PLANE**, the **LOOP(s)** must not contain any reference geometry
- If the **SURFACE** is not a **PLANE** then the **LOOP's** reference Object must match that of the **FACE**
- The orientation of the **FACE** is either **SFORWARD** (where the **SURFACE's** natural normal ($U \times V$) matches the **FACE**) or **SREVERSE** when the orientations are apposed. Note that this is coupled with the **LOOP's** orientation (i.e. an outer **LOOP** traverses the **FACE** in a right-handed manner defining the outward direction)



Objects -- Topology

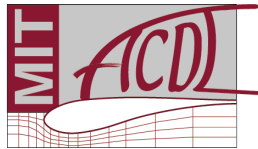


- **SHELL**

- A collection of one or more connected **FACES** that (if **CLOSED**) segregates regions of 3-Space
- All **FACES** must be properly oriented
- **SHELLS** can be either **OPEN** or **CLOSED**
- Non-manifold **SHELLS** can have more than 2 **FACES** sharing an **EDGE** (**OPEN** in this case)

- **SOLIDBODY**

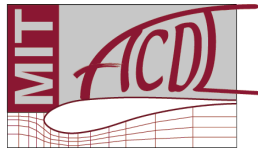
- A manifold collection of one or more **CLOSED SHELLS** with associated senses
- There may be only one outer **SHELL** (sense = 1) and any number of inner **SHELLS** (sense = -1)



Objects -- Topology



- **BODY** (including **SOLIDBODY**)
 - Container used to aggregate Topology
 - Connected but non-manifold at the **MODEL** level
 - A **WIREBODY** contains a single **LOOP**
 - A **FACEBODY** contains a single **FACE**
 - A **SHEETBODY** contains a single **SHELL** which can be either non-manifold or manifold (though usually manifold bodies of this type are promoted to **SOLIDBODYs**)
- **MODEL**
 - A collection of **BODIES**
 - Can be treated like Assemblies
 - This is Read and Written by **EGADS**



Objects -- Tessellation



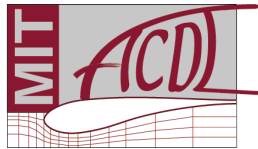
Discrete representation of another Object

- **Geometry**

- Unconnected discretization of a range of the Object
 - PolyLine for **CURVEs** at constant t increments
 - Regular Grid for **SURFACEs** at constant increments

- **Body Topology**

- Connected and trimmed tessellation including:
 - PolyLine for **EDGEs**
 - Triangulation for **FACEs**
 - Optional Quadrilateral Patching for **FACEs**
- Ownership and Geometric Parameters for Vertices
- Adjustable Parameters for side length and curvature
- Watertight

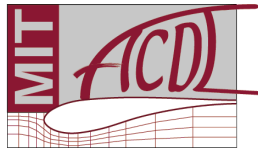


Objects -- Tessellation



Control of the use of Quadrilateral Templates

- Automatic with triangulation scheme
- Attempts to Isolate 3 or 4 “sides”
 - Only single **LOOPS**
 - **FACES** with more than 4 **EDGES** are analyzed to see if multiple **EDGES** can be treated as a single “side”
- Point counts on sides (based on **EDGE** Tessellation) are used:
 - TFI if opposites are equal
 - Templates otherwise
- Defeated/modified with **BODY** attribute “.qParams”
 - If ATTRSTRING -- turn off quadding templates
 - If ATTRREAL (3 in length):
 1. EDGE matching expressed as the deviation from alignment [default: 0.05]
 2. Maximum quad *side* ratio point count to allow [default: 3.0]
 3. Number of smoothing iterations [default: 0.0]

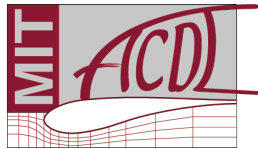


Objects -- Tessellation



Watertight Quadrilateral FACE Treatment

- Manual
- Requires Existing Topologic Tessellation
- Must be able to Isolate 4 “sides”
 - Only single **LOOPS**
 - **FACES** with more than 4 **EDGES** are analyzed to see if multiple **EDGES** can be treated as a single “side”
 - Currently no DEGENERATE **EDGES**
- Point counts on sides (based on **EDGE** Tessellation) are used:
 - TFI if opposites are equal
 - Templates otherwise
- **EDGE** Tessellation Adjustment Functions
 - When point counts don't allow for Quadding

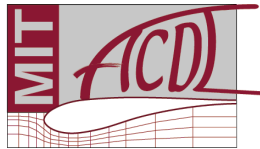


Objects -- Tessellation



Using Tessellations for Finite-Differences

- Useful for Parametric Sensitivities in a parameter driven build system
- Requires the same Topologic structure between Bodies (may need a *mapping*)
- BSpline **SURFACES** (on mapped **FACES**) must have the same knot sequences (note: the knots define the $[u,v]$ parametrization).
- This is accomplished by 2 EGADS functions:
 - `EG_mapBody` – sets up the mapping if required
 - `EG_mapTessBody` – builds the tessellation from a source
- These functions respond to mapped indices:
 - `EG_getTessEdge`
 - `EG_getTessFace`
 - `EG_locateTessBody`



Objects -- Others

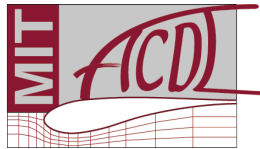


- **TRANSFORM**

- Used when copying Objects to change the root position and orientation

- **REFERENCE**

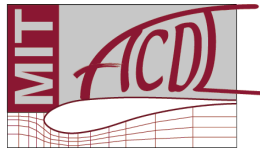
- Allows of the management of Objects that refer to other Objects (so that deletion does not invalidate the data)
- This is an internal Object and is not usually seen by the EGADS programmer.



Objects -- Lifetime & Scope



- **BODY**
 - When made, copies of all referenced objects are created and stored
- **MODEL**
 - A **BODY** can be included in only one **MODEL** (you will get a “reference error” if violated)
 - Copy the **BODY** if it is needed in a second **MODEL**
- **Others**
 - Unconnected (at the **BODY**-level) Geometric & Topologic Objects can be deleted *en masse* by invoking `EG_deleteObject` on the **CONTEXT**



API -- Utility & IO Functions



- **open**

```
icode = EG_open(ego *context)
icode = IG_open(I*8 context)
```

Opens and returns a **CONTEXT** object. Note that the **Context** is the beginning of the threaded list of objects.

- **free**

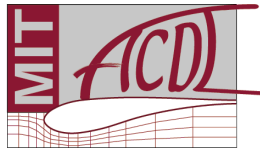
```
EG_free(void *ptr)
call IG_free(cptr ptr)
```

Used to free up a pointer returned from EGADS if marked as “freeable”

- **deleteObject**

```
icode = EG_deleteObject(ego object)
icode = IG_deleteObject(I*8 object)
```

Deletes an Object (if possible). A positive return indicates that the object is still referenced by this number of other objects and has not been removed from the context. If the object is the context then all objects in the context are deleted except those attached to **BODY** or **MODEL** objects.



API -- Utility & IO Functions



- **getContext**

```
icode = EG_getContext(ego object, ego *context)
icode = IG_getContext(I*8 object, I*8 context)
```

Returns the **CONTEXT** given an object

- **setOutLevel**

```
icode = EG_setOutLevel(ego context, int outLevel)
icode = IG_setOutLevel(I*8 context, I*4 outLevel)
```

Sets the EGADS verbose level (0-silent to 3-debug), The default is 1.
Success returns the old output level.

- **close**

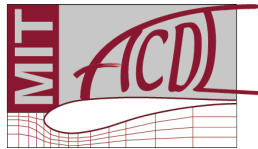
```
icode = EG_close(ego context)
icode = IG_close(I*8 context)
```

Cleans up and closes the **CONTEXT**

- **revision**

```
EG_revision(int *major, int *minor, char **OCCrev)
call IG_revision(I*4 major, I*4 minor, C** OCCrev)
```

Returns the version information for EGADS and OpenCASCADE



API -- Utility & IO Functions



- **loadModel**

```
icode = EG_loadModel(ego context, int flags,  
                    char *name,  ego *model)  
icode = IG_loadModel(I*8 context, I*4 flags,  
                    C** name,   I*8 model)
```

Loads and returns a **MODEL** object from disk and put it in the **CONTEXT**.

flags:

1 - Don't split closed and periodic entities

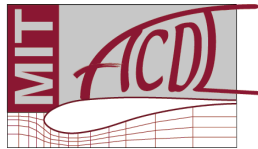
name: Load by extension

- igs/iges
- stp/step
- brep (for native OpenCASCADE files)
- egads (for native files with persistent Attributes, split ignored)

- **saveModel**

```
icode = EG_saveModel(ego model, char *name)  
icode = IG_saveModel(I*8 model, C** name)
```

Saves the **MODEL** to disk based on the filename extension.



API -- Utility & IO Functions



- **getTransform**

```
icode = EG_getTransform(ego oform, double *xform)
icode = IG_getTransform(I*8 oform, R*8      xform)
```

Returns the transformation information. This appears like is a column-major matrix that is 4 columns by 3 rows and could be thought of as [3][4] in C (though is flat) and in FORTRAN dimensioned as (4,3).

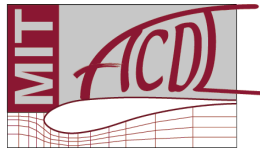
oform the transformation object

xform a vector of double precision reals at least 12 in length

- **makeTransform**

```
icode = EG_makeTransform(ego context, double *xform,
                        ego *oform)
icode = IG_makeTransform(I*8 context, R*8      xform,
                        I*8  oform)
```

Creates a **TRANSFORM** object from the 12 values. The rotation portion [3][3] must be “scaled” orthonormal (orthogonal with a single scale factor).



API -- Utility & IO Functions



- **copyObject**

```
icode = EG_copyObject(ego object, ego oform,  
                      ego *newObject)  
icode = IG_copyObject(I*8 object, I*8 oform,  
                      I*8 newObject)
```

Creates a new EGADS object by copying and transforming the input object.

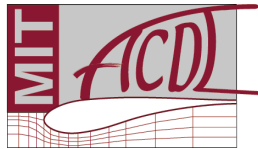
object the input object (3D geometry or topology)
oform the transformation object (may be NULL for a strict copy)
newObject the resultant new object

- **flipObject**

```
icode = EG_flipObject(ego object, ego *newObject)  
icode = IG_flipObject(I*8 object, I*8 newObject)
```

Creates a new EGADS object by copying and reversing the input object.

object the input object: 3D geometry (flip the parameterization) or topology
 (reverse the sense). Not for NODE, EDGE, BODY or MODEL. SURFACES
 reverse only the u parameter.
newObject the resultant new flipped object



API -- Utility & IO Functions



- **getInfo**

```
icode = EG_getInfo(ego object,  int *oclass, int *mtype,  
                  ego *topRef, ego *prev,  ego *next)  
icode = IG_getInfo(I*8 object,  I*4 oclass, I*4 mtype,  
                  I*8 topRef,  I*8 prev,   I*8 next)
```

Returns information about the object:

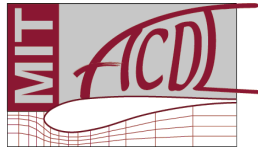
oclass CONTEXT, TRANSFORM, TESSELLATION, REFERENCE,
 PCURVE, CURVE, SURFACE,
 NODE, EGDE, LOOP, FACE, SHELL, BODY, MODEL

mtype PCURVE/CURVE
 LINE, CIRCLE, ELLIPSE, PARABOLA, HYPERBOLA, TRIMMED,
 BEZIER, BSPLINE, OFFSET
 SURFACE
 PLANE, SPHERICAL, CYLINDRICAL, REVOLUTION, TORIODAL,
 TRIMMED, BEZIER, BSPLINE, OFFSET, CONICAL, EXTRUSION
 EDGE is TWONODE, ONENODE or DEGENERATE
 LOOP is OPEN or CLOSED
 FACE is either SFORWARD or SREVERSE
 SHELL is OPEN or CLOSED
 BODY is either WIREBODY, FACEBODY, SHEETBODY or SOLIDBODY

topRef is the top level BODY/MODEL that owns the object or context (if top)

prev is the previous object in the threaded list (NULL at CONTEXT)

next is the next object in the list (NULL is the end of the list)



API -- Utility & IO Functions



Additional Memory Functions for the FORTRAN Bindings

- **alloc**

`icode = IG_alloc(I*4 nbytes, CPTR ptr)`

Allocates a block of memory

- **calloc**

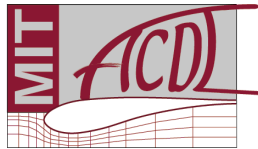
`icode = IG_calloc(I*4 nele, I*4 size, CPTR ptr)`

Allocates a zero fills a block of memory

- **reall**

`icode = IG_reall(CPTR ptr, I*4 nbytes)`

Reallocates a block of memory



API -- Attribution

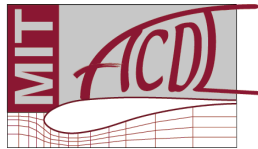


- **attributeAdd**

```
icode = EG_attributeAdd(ego object, char *name, int atype,  
                        int len, int *ints, double *reals,  
                        char *string)  
icode = IG_attributeAdd(I*8 object, C** name, I*4 atype,  
                        I*4 len, I*4 ints, R*8 reals,  
                        C** string)
```

Adds an attribute to the object. If an attribute exists with the name it is overwritten with the new information.

object the object
name the name of the attribute. Must not contain a space or other special characters
atype must be either:
 ATTRINT for integers
 ATTRREAL for double precision
 ATTRSTRING for a character string
len the number of integers or reals (ignored for strings)
ints the integers for ATTRINT
reals the floating point data for ATTRREAL
string the character string for an ATTRSTRING type



Note: Only the appropriate one (of ints, reals or string) is required

API -- Attribution



- **attributeDel**

```
icode = EG_attributeDel(ego object, char *name)
icode = IG_attributeDel(I*8 object, C** name)
```

Deletes an attribute from the object. If the name is NULL then all attributes are removed from this object.

object the object

name the name of the attribute.

FORTTRAN can use a string containing just space(s) to indicate NULL

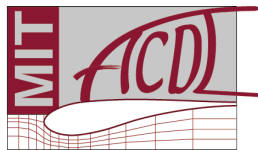
- **attributeNum**

```
icode = EG_attributeNum(ego object, int *nattr)
icode = IG_attributeNum(I*8 object, I*4 nattr)
```

Returns the number of attributes found with this object.

object the object

nattr the number of attributes



API -- Attribution



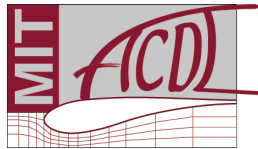
- **attributeGet**

```
icode = EG_attributeGet(ego object, int index, char **name,  
                        int *atype, int *len, int **pints,  
                        double **preals, char **string)  
icode = IG_attributeGet(I*8 object, I*4 index, C** name,  
                        I*4 atype, I*4 len, CPTR pints,  
                        R*8 preals, C** string)
```

Retrieves a specific attribute from the object.

object the object
index the index (1 to num from **attributeNum**)
name the returned name of the attribute
atype the returned type: ATTRINT, ATTRREAL or ATTRSTRING
len the returned length for integers or reals
pints a pointer to integer(s) for ATTRINT
preals a pointer to the floating point data for ATTRREAL
string the returned character string for an ATTRSTRING type

Notes: (1) Only the appropriate one (of pints, preals or string) is returned
(2) Care must be taken with name and string in FORTRAN not to overstep the declared CHARACTER length



API -- Attribution



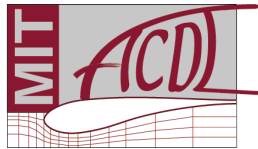
- **attributeRet**

```
icode = EG_attributeRet(ego object, char *name, int *atype,  
                        int *len, int **pints, double **preals,  
                        char **string)  
icode = IG_attributeRet(I*8 object, C** name, I*4 atype,  
                        I*4 len, CPTR pints, R*8 preals,  
                        C** string)
```

Retrieves an attribute by name from the object.

object the object
name the name of the attribute to return
atype the returned type: ATTRINT, ATTRREAL or ATTRSTRING
len the returned length for integers or reals
pints a pointer to integer(s) for ATTRINT
preals a pointer to the floating point data for ATTRREAL
string the returned character string for an ATTRSTRING type

Notes: (1) Only the appropriate one (of pints, preals or string) is returned
(2) Care must be taken with the string variable in FORTRAN not to overstep the declared CHARACTER length



API -- Attribution



- **attributeDup**

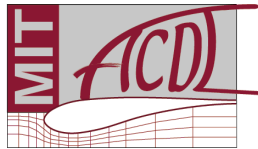
```
icode = EG_attributeDup(ego src, ego dst)
```

```
icode = IG_attributeDup(I*8 src, I*8 dst)
```

Removes all attributes from the destination object, then copies the attributes from the source.

src the source object

dst the destination object



API -- Geometry



- **getGeometry**

```
icode = EG_getGeometry(ego object, int *oclass, int *mtype,  
                       ego *rGeom, int **pinfo, double **prv)  
icode = IG_getGeometry(I*8 object, I*4 oclass, I*4 mtype,  
                       I*8 rGeom, CPTR pinfo, CPTR prv)
```

Returns information about the geometric object:

oclass PCURVE, CURVE or SURFACE

mtype PCURVE/CURVE

LINE, CIRCLE, ELLIPSE, PARABOLA, HYPERBOLA, TRIMMED,
BEZIER, BSPLINE, OFFSET

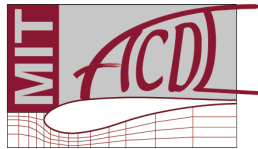
SURFACE

PLANE, SPHERICAL, CYLINDRICAL, REVOLUTION, TORIODAL,
TRIMMED, BEZIER, BSPLINE, OFFSET, CONICAL, EXTRUSION

rGeom is the reference geometry object (if none this is returned as NULL)

pinfo is a returned pointer to the block of integer information. Filled for
either BEZIER or BSPLINE, and when nonNULL is *freeable*.

prv is the returned pointer to a block of double precision reals. The
content and length depends on the oclass/mtype (*freeable*).



API -- Geometry

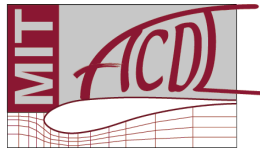


- **makeGeometry**

```
icode = EG_makeGeometry(ego ctxt, int oclass, int mtype, ego rGeom,  
                        int *pinfo, double *prv, ego *geom)  
icode = IG_makeGeometry(I*8 ctxt, I*4 oclass, I*4 mtype, I*8 rGeom,  
                        CPTR pinfo, CPTR prv, I*8 geom)
```

Creates a geometric object:

ctxt the **CONTEXT** object
oclass PCURVE, CURVE or SURFACE
mtype PCURVE/CURVE
 LINE, CIRCLE, ELLIPSE, PARABOLA, HYPERBOLA, TRIMMED,
 BEZIER, BSPLINE, OFFSET
 SURFACE
 PLANE, SPHERICAL, CYLINDRICAL, REVOLUTION, TORIODAL,
 TRIMMED, BEZIER, BSPLINE, OFFSET, CONICAL, EXTRUSION
rGeom is the reference geometry object (if none use NULL)
pinfo is a pointer to the block of integer information. Required for
 either BEZIER or BSPLINE.
prv is the pointer to a block of double precision reals. The
 content and length depends on the oclass/mtype.
geom is the resultant new geometry object



API -- Geometry



- **getRange**

```
icode = EG_getRange(ego object, double *range, int *periodic)
icode = IG_getRange(I*8 object, R*8 range, I*4 periodic)
```

Returns the valid range of the object:

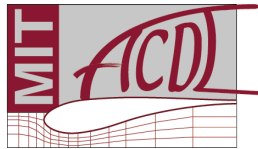
object may be one of PCURVE, CURVE, SURFACE, EDGE or FACE
range for PCURVE, CURVE or EDGE returns 2 values:
 t -start and t -end
 for SURFACE or FACE returns 4 values:
 u -min, u -max, v -min and v -max
periodic: 0 for non-periodic, 1 for periodic in t or u
 2 for periodic in v (or-able)

- **arcLength**

```
icode = EG_arcLength(ego obj, double t1, double t2, double *alen)
icode = IG_arcLength(I*8 obj, R*8 t1, R*8 t2, R*8 alen)
```

Returns the arc-length of an object.

obj may be one of PCURVE, CURVE or EDGE
t1 starting t
t2 terminating t for calculation
alen arc-length (returned)



API -- Geometry



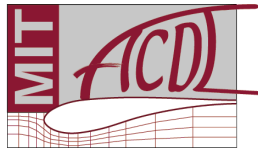
- evaluate**

```
icode = EG_evaluate(ego object, double *parms, double *eval)
icode = IG_evaluate(I*8 object, R*8 parms, R*8 eval)
```

Returns the result of evaluating on the object:

object may be one of PCURVE, CURVE, SURFACE, EDGE or FACE
 parms parameter(s) used to evaluate on the object:
 for PCURVE, CURVE or EDGE the one value is t
 for SURFACE or FACE the 2 values are u then v
 eval the returned position, 1st and 2nd derivatives (length):

	<u>PCurve (6)</u>	<u>Edge -or- Curve (9)</u>	<u>Face -or- Surface (18)</u>
Position	$[u,v]$	$[x,y,z]$	$[x,y,z]$
1st Derivative	$[du,dv]$	$[dx,dy,dz]$	$[dx_u,dy_u,dz_u]$ $[dx_v,dy_v,dz_v]$
2nd Derivative	$[du^2,dv^2]$	$[dx^2,dy^2,dz^2]$	$[dx_u^2,dy_u^2,dz_u^2]$ $[dx_{uv},dy_{uv},dz_{uv}]$ $[dx_v^2,dy_v^2,dz_v^2]$



API -- Geometry

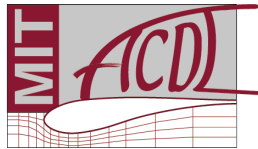


- **invEvaluate**

```
icode = EG_invEvaluate(ego object,    double *pos,  
                      double *parms, double *result)  
icode = IG_invEvaluate(I*8 object,    R*8    pos,  
                      R*8    parms, R*8    result)
```

Returns the result of inverse evaluation on the object. For topology the result is limited to inside the EGDE/FACE valid bounds.

object	may be one of PCURVE, CURVE, SURFACE, EDGE or FACE
pos	is $[u,v]$ for a PCURVE and $[x,y,z]$ for all others
parms	the returned parameter(s) found for the nearest position on the object: for PCURVE, CURVE or EDGE the one value is t for SURFACE or FACE the 2 values are u then v
result	the closest position found is returned: $[u,v]$ for a PCURVE (2) and $[x,y,z]$ for all others (3)



API -- Geometry



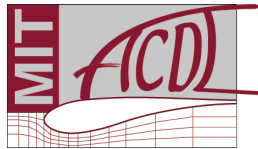
- **curvature**

```
icode = EG_curvature(ego object, double *parms, double *crva)
icode = IG_curvature(I*8 object, R*8      parms, R*8      crva)
```

Returns the curvature and principle directions/tangents:

object may be one of PCURVE, CURVE, SURFACE, EDGE or FACE
parms parameter(s) used to evaluate on the object:
 for PCURVE, CURVE or EDGE the one value is t
 for SURFACE or FACE the 2 values are u then v
crva the returned curvature information (length):

<u>PCurve (3)</u>	<u>Edge -or- Curve (4)</u>	<u>Face -or- Surface (8)</u>
curvature	curvature	curvature1
$[dir.x, dir.y]$	$[dir.x, dir.y, dir.z]$	$[dir1.x, dir1.y, dir1.z]$
		curvature2
		$[dir2.x, dir2.y, dir2.z]$



API -- Geometry

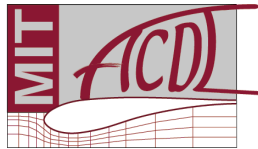


- **approximate**

```
icode = EG_approximate(ego context, int mDeg, double tol,  
                      int *sizes, double *xyz, ego *geo)  
icode = IG_approximate(I*8 context, I*4 mDeg, R*8 tol,  
                      I*4 sizes, R*8 xyz, I*8 geo)
```

Computes and returns the resultant geometry object created by approximating the data by a BSpline (OCC or EGADS method).

context	the CONTEXT object used to place the result
mDeg	the maximum degree used by OCC [3-8], or cubic by EGADS [0-2] 0 – fixes the bounds and uses natural end conditions 1 – fixes the bounds and maintains the slope input at the bounds 2 – fixes the bounds & quadratically maintains the slope at 2 nd order
tol	is the tolerance to use for the BSpline approximation procedure, zero for a SURFACE fit (OCC).
sizes	a vector of 2 integers that specifies the size and dimensionality of the data. If the second is zero, then a CURVE is fit and the first integer is the length of the number of $[x,y,z]$ triads. If the second integer is nonzero then the input data reflects a 2D map.
xyz	the data to fit (3 times the number of points in length)
geo	the returned approximated (or fit) BSpline resultant object



API -- Geometry



- **otherCurve**

```
icode = EG_otherCurve(ego surface, ego iCrv, double tol,  
                      ego *oCrv)  
icode = IG_otherCurve(I*8 surface, I*8 iCrv, R*8 tol,  
                      I*8 oCrv)
```

Computes and returns the *other* curve that matches the input curve. If the input curve is a PCURVE, the output is a 3D CURVE (and *vice versa*).

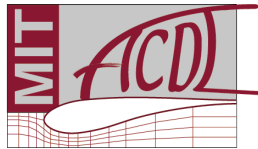
surface the **SURFACE** object used for the conversion
iCrv the input **PCURVE** or **CURVE** object
tol is the tolerance to use when fitting the output curve
oCrv the returned approximated resultant curve object

- **isSame**

```
icode = EG_isSame(ego obj1, ego obj2)  
icode = IG_isSame(I*8 obj1, I*8 obj2)
```

Compares two objects for geometric equivalence.

obj1 an object of type **CURVE**, **EDGE**, **SURFACE** or **FACE**
obj2 an object of the same dimensionality



API -- Geometry



- **isoCline**

```
icode = EG_isoCline(ego surface, int iUV, double value,  
                    ego *oCrv)  
icode = IG_isoCline(I*8 surface, I*4 iUV, R*8 value,  
                    I*8 oCrv)
```

Computes from the input Surface and returns the isocline curve.

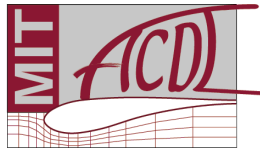
surface the **SURFACE** object used for the source
iUV the type of isocline: **UIISO** (0) constant U or **VIISO** (1) constant V
value the value used for the isocline
oCrv the returned resultant curve object

- **convertToBSpline**

```
icode = EG_convertToBSpline(ego geom, ego *bspline)  
icode = IG_convertToBSpline(I*8 geom, I*8 bspline)
```

Computes and returns the BSpline representation of the input geometric object.

geom can be a **CURVE**, **EDGE**, **SURFACE** or **FACE**
bspline the returned approximated resultant **BSPLINE** object



API -- Topology



- **getTopology**

```
icode = EG_getTopology(ego object, ego      *ref, int *oclass,  
                      int *mtype, double *data, int *nchild,  
                      ego **pchldrn, int **psens)  
icode = IG_getTopology(I*8 object, I*8      ref, I*4  oclass,  
                      I*4 mtype, R*8      data, I*4  nchild,  
                      CPTR  pchldrn, CPTR  psens)
```

Returns information about the topological object:

ref is the reference geometry object (if none this is returned as NULL)

oclass is NODE, EGDE, LOOP, FACE, SHELL, BODY or MODEL

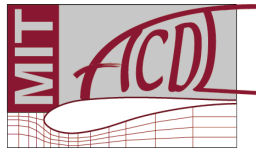
mtype for EDGE is TWONODE, ONENODE or DEGENERATE
for LOOP is OPEN or CLOSED
for FACE is either SFORWARD or SREVERSE
for SHELL is OPEN or CLOSED
BODY is either WIREBODY, FACEBODY, SHEETBODY or SOLIDBODY

data will retrieve at most 4 doubles:
for NODE this contains the $[x,y,z]$ location
EDGE is the t -min and t -max (the parametric bounds)
FACE returns the $[u,v]$ box (the limits first for u then for v)

nchild number of children (lesser) topological objects

pchldrn is a returned pointer to the block of children objects.
FORTRAN only note: this pointer is *freeable*.

psens is the returned pointer to a block of integer senses for the children.



API -- Topology



- **makeTopology**

```
icode = EG_makeTopology(ego context, ego ref, int oclass,  
                        int mtype, double *data, int nchild,  
                        ego *chldrn, int *senses, ego *topo)  
icode = IG_makeTopology(I*8 context, I*8 ref, I*4 oclass,  
                        I*4 mtype, R*8 data, I*4 nchild,  
                        I*8 chldrn, I*4 senses, I*8 topo)
```

Creates and returns a topological object:

context the CONTEXT object used to place the result

ref reference geometry object required for EDGES and FACES (optional for LOOP)

oclass is either NODE, EGDE, LOOP, FACE, SHELL, BODY or MODEL

mtype for EDGE is TWONODE, ONENODE or DEGENERATE

for LOOP is OPEN or CLOSED

for FACE is either SFORWARD or SREVERSE

for SHELL is OPEN or CLOSED

BODY is either WIREBODY, FACEBODY, SHEETBODY or SOLIDBODY

data may be NULL except for:

NODE which contains the $[x,y,z]$ location

EDGE is the t -min and t -max (the parametric bounds)

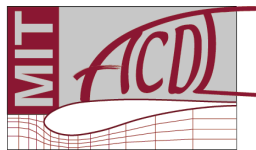
nchild number of children (lesser) topological objects

chldrn a vector of children objects (nchild in length)

if LOOP and has reference SURFACE, then $2*nchild$ in length (PCURVES follow)

senses a vector of integer senses for the children (required for FACES & LOOPS only)

topo the resultant returned topological object



API -- Topology



- **makeFace**

```
icode = EG_makeFace(ego object, int mtype, double *data,  
                    ego *face)  
icode = IG_makeFace(I*8 object, I*4 mtype, R*8 data,  
                    I*8 face)
```

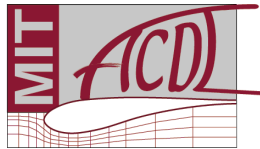
Creates a simple FACE from a LOOP or a SURFACE. Also can be used to hollow a single LOOPed existing FACE. This function creates any required NODEs, EDGEs and LOOPs.

object either a LOOP (for a planar *cap*), a SURFACE with $[u,v]$ bounds, or a FACE to be hollowed out

mtype is either SFORWARD or SREVERSE
for LOOPS you may want to look at the orientation using **getArea**, ignored when the input object is a FACE

data may be NULL for LOOPS, but must be the limits for a SURFACE (4 values), the hollow/offset distance and fillet radius (zero is for no fillets) for a FACE input object (2 values)

face the resultant returned topological FACE object (a return of **EGADS_OUTSIDE** is the indication that offset distance was too large to produce any cutouts, and this result is the input object)



API -- Topology



- **makeSolidBody**

```
icode = EG_makeSolidBody(ego context,  int stype,  
                           double *data, ego *body)  
icode = IG_makeSolidBody(I*8 context,  I*4 stype,  
                           R*8      data, I*8  body)
```

Creates a simple SOLIDBODY. Can be either a box, cylinder, sphere, cone, or torus.

context the CONTEXT object used to place the result

stype 1-box, 2-sphere, 3-cone, 4-cylinder, or 5-torus

data depends on stype:

box (6): $[x,y,z]$ then $[dx,dy,dz]$ for size of box

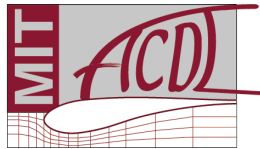
sphere (4): $[x,y,z]$ of center then radius

cone (7): apex $[x,y,z]$, base center $[x,y,z]$, then radius

cylinder (7): 2 axis points and the radius

torus (8): $[x,y,z]$ of center, direction of rotation, then
major radius and minor radius

body the resultant returned topological BODY object



API -- Topology



- **getBodyTopos**

```
icode = EG_getBodyTopos(ego body,    ego *ref,  int oclass,
                        int *ntopo,  ego **ptopos)
icode = IG_getBodyTopos(I*8 body,    I*8  ref,  I*4 oclass,
                        I*4  ntopo,  CPTR  ptopos)
```

Returns topologically connected objects:

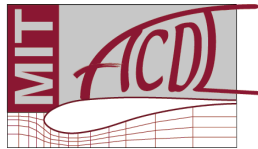
body body container object
ref reference topological object or NULL. Sets the context for the returned objects
 (i.e. all objects of a class [*oclass*] in the tree looking towards that class from *ref*)
 NULL starts from the BODY (for example all NODEs in the BODY)
oclass is NODE, EGDE, LOOP, FACE or SHELL -- must not be the same class as *ref*
ntopo the returned number of requested topological objects
ptopos is a returned pointer to the block of objects (*freeable*)

- **indexBodyTopo**

```
index = EG_indexBodyTopo(ego body, ego *obj)
index = IG_indexBodyTopo(I*8 body, I*8  obj)
```

Returns the index (bias 1) of the topological object in the Body:

body body container object
obj is the topological object in the Body



API -- Topology



- **getArea**

```
icode = EG_getArea(ego object, double *data, double *area)
icode = IG_getArea(I*8 object, R*8 data, R*8 area)
```

Computes the surface area from a LOOP, a SURFACE or a FACE.
When a LOOP is used a planar surface is fit and the resultant area can be negative if the orientation of the fit is opposite of the LOOP.

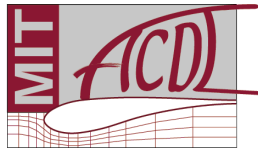
object either a LOOP (for a planar *cap*), a SURFACE with $[u,v]$ bounds or a FACE
data may be NULL except must contain the limits for a SURFACE
area the resultant surface area returned

- **getBoundingBox**

```
icode = EG_getBoundingBox(ego object, double *box)
icode = IG_getBoundingBox(I*8 object, R*8 box)
```

Computes the Cartesian bounding box around the object:

object any topological object
box 6 doubles reflecting the $[x,y,z]$ min and $[x,y,z]$ max



API -- Topology



- **getMassProperties**

```
icode = EG_getMassProperties(ego topo, double *data)
icode = IG_getMassProperties(I*8 topo, R*8 data)
```

Computes and returns the physical and inertial properties of a topological object.

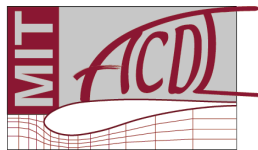
topo the object, can be EDGE, FACE, SHELL, BODY or MODEL
data the data returned (must be declared to at least 14 doubles):
 volume, surface area (length for EDGE)
 center of gravity (3)
 inertia matrix at CoG (9)

- **isEquivalent**

```
icode = EG_isEquivalent(ego topo1, ego topo2)
icode = IG_isEquivalent(I*8 topo1, I*8 topo2)
```

Compares two topological objects for equivalence. Note: topological objects in different bodies will have different object pointers.

topo1 a topological object
topo2 a topological object of the same class



API -- Topology



- **inTopology**

```
icode = EG_inTopology(ego topo, double *xyz)
icode = IG_inTopology(I*8 topo, R*8 xyz)
```

Computes whether the point is on or contained within the object. Works with EDGES and FACES by projection. SHELLS must be CLOSED.

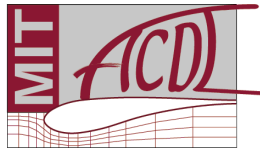
topo the object, can be EDGE, FACE, SHELL or SOLIDBODY
xyz the coordinate location to check
icode the result or error code

- **inFace**

```
icode = EG_inFace(ego face, double *uv)
icode = IG_inFace(I*8 face, R*8 uv)
```

Computes the result of the $[u,v]$ location in the valid part of the FACE.

face the FACE object
uv the parametric location to check
icode the result or error code



API -- Topology

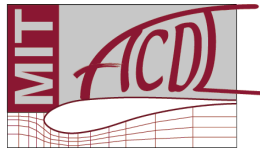


- **getEdgeUV**

```
icode = EG_getEdgeUV(ego face, ego edge, int sense,  
                     double t, double *uv)  
icode = IG_getEdgeUV(I*8 face, I*8 edge, I*4 sense,  
                     R*8 t, R*8 uv)
```

Computes on the EDGE/PCURVE to get the appropriate $[u,v]$ on the FACE.

face	the FACE object
edge	the EDGE object
sense	can be 0, but must be specified if the EDGE is found the the FACE twice. This uniquely specifies which position to use when the FACE closes on itself.
t	the parametric value to use for the evaluation
uv	the resulting $[u,v]$ evaluated at t .



API -- Topology



- **sewFaces**

```
icode = EG_sewFaces(int nObject, ego *objects, double tol,  
                    int flag, ego *model)  
icode = IG_sewFaces(I*4 nObject, I*8 objects, R*8 tol,  
                    int flag, I*8 model)
```

Creates a MODEL from a collection of Objects. The Objects can be either FACEBODYs and/or FACES. After the sewing operation, any unconnected Objects are returned as FACEBODYs.

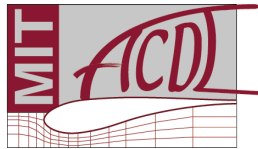
nObject the number of Objects in the list
objects list of FACEBODY and/or FACES to sew together (nObject in length)
toler tolerance used for the operation (0.0 - use Face tolerances)
flag 0 - manifold, 1 - allow non-manifold results
model the resultant MODEL object

- **getTolerance**

```
icode = EG_getTolerance(ego object, double *tol)  
icode = IG_getTolerance(I*8 object, R*8 tol)
```

Returns the internal tolerance defined for the object.

object topological object (all except MODEL)
tol the tolerance used to define closure



API -- Topology

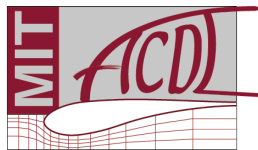


- **replaceFaces**

```
icode = EG_replaceFaces(ego body, int nFace, ego *faces,  
                        ego *result)  
icode = IG_replaceFaces(I*8 body, I*4 nFace, I*8 faces,  
                        I*8 result)
```

Creates a new SHEETBODY or SOLIDBODY from an input SHEETBODY or SOLIDBODY and a list of FACES to modify. The FACES are input in pairs where the first must be an Object in the BODY and the second either a new FACE or NULL. The NULL replacement flags removal of the FACE in the BODY.

body	body container object Note: SOLIDBODYs must have a single (outer) SHELL
nFace	the number of FACE pairs in the list
faces	list of FACE pairs, where the first must be a FACE in the BODY and second is either the FACE to use as a replacement or a NULL which indicates that the FACE is to be removed from the BODY 2*nFace in length
result	the resultant BODY object, either a SHEETBODY or a SOLIDBODY (where the input was a SOLIDBODY and all FACES are replaced in a way that the LOOPS match up)



API -- Topology



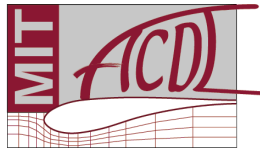
- **matchBodyFaces**

```
icode = EG_matchBodyFaces(ego body1,  ego body2,  
                           int *nMatch, int **matches)  
  
icode = IG_matchBodyFaces(I*8 body1,  I*8 body2,  
                           I*4  nMatch, CPTR  matches)
```

Examines the FACES in one BODY against all of the FACES in another. If the FACE bounding boxes, number of LOOPS, number of NODEs, the NODE locations, the number of EDGES and the EDGE bounding boxes as well as the EDGE arc lengths match it is assumed that the FACES match. A list of pairs of indices are returned.

body1 first body container object
body2 second body container object
nMatch the number of matched FACE pairs in the list
matches pointer to a list of FACE pairs, returned as NULL if nMatch is zero,
 otherwise it is a pointer to 2*nMatch integers, where each pair
 is the matching indices in the respective bodies (freeable)

Note: This is useful for the situation where there are *glancing* FACES and a UNION operation fails (or would fail). Simply find the matching FACES and do not include them in a call to **EG_sewFaces**.



API -- Topology / Tessellation



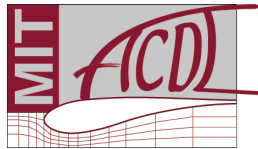
- **mapBody**

```
icode = EG_mapBody(ego src, ego dst, char *fAttr,  
                  ego *mapped)  
icode = IG_mapBody(I*8 src, I*8 dst, C** fAttr,  
                  I*8 mapped)
```

Checks for topological equivalence between the the BODY *src* and the BODY *dst*. If necessary, produces a mapping (indices in *src* which map to *dst*) and places these as attributes on the resultant BODY *mapped* (named *.nMap*, *.eMap* and *.fMap*). Also may modify BSplines associated with FACES.

src source body object (not WIREBODY)
dst destination body object
fAttr the FACE attribute used to map FACES
mapped the mapped resultant BODY object copied from *dst*
 If NULL and *icode* == EGADS_SUCCESS, *dst* is equivalent and can
 be used directly in **EG_mapTessBody**

Note: It is the responsibility of the caller to have uniquely attributed all FACES in both *src* and *dst* to aid in the mapping for all but FACEBODYS.



API -- Tessellation

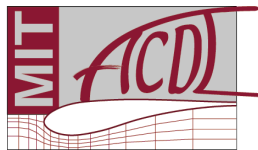


- **makeTessGeom**

```
icode = EG_makeTessGeom(ego geom, double *limits, int *sizes,  
                        ego *tess)  
icode = IG_makeTessGeom(I*8 geom, R*8      limits, I*4  sizes,  
                        I*8  tess)
```

Creates a discretization object from a geometry-based Object.

geom	the input object, may be a CURVE or SURFACE
limits	the bounds of the tessellation (like range)
sizes	a set of 2 integers that specifies the size and dimensionality of the data. The second is assumed zero for a CURVE and in this case the first integer is the length of the number of evenly spaced (in t) points created. The second integer must be nonzero for SURFACES and this then specifies the density of the $[u,v]$ map of coordinates produced (again evenly spaced in the parametric space). If a value of sizes is negative, then the fill is reversed for that coordinate.
tess	the resultant TESSELLATION object



API -- Tessellation



- **getTessGeom**

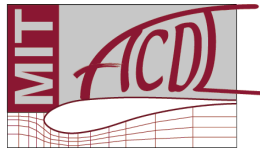
```
icode = EG_getTessGeom(ego tess, int *sizes, double **pxyz)
icode = IG_getTessGeom(I*8 tess, I*4 sizes, CPTR pxyz)
```

Retrieves the data associated with the discretization of a geometry-based Object.

tess the TESSELLATION object

sizes a returned set of 2 integers that specifies the size and dimensionality of the data. If the second is zero, then it is from a CURVE and the first integer is the length of the number of $[x,y,z]$ triads. If the second integer is nonzero then the input data reflects a 2D map of coordinates.

pxyz the returned pointer to the suite of coordinate data.



API -- Tessellation



- **makeTessBody**

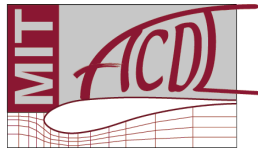
```
icode = EG_makeTessBody(ego body, double *parms, ego *tess)
icode = IG_makeTessBody(I*8 body, R*8      parms, I*8  tess)
```

Creates a discretization object from a Topological BODY Object.

body the input object, may be any Body type.

parms 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.

tess the resultant TESSELLATION object where each EDGE in the BODY is discretized and each FACE is triangulated.



API -- Tessellation

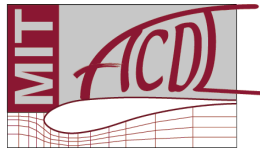


- **remakeTess**

```
icode = EG_remakeTess(ego tess, int nobj, ego *facedg, double *parms)  
icode = IG_remakeTess(I*8 tess, I*4 nobj, I*8 facedg, R*8 parms)
```

Redoes the discretization for specified objects from within a BODY TESSELLATION.

tess the TESSELLATION object to modify.
nobj number of objects in the face/edge list.
facedg list of FACE and/or EDGE objects from within the BODY used to
 create the TESSELLATION object. First all specified Edges are
 rediscretized. Then any listed Face and the Faces touched by the
 retessellated Edges are retriangulated. Note that Quad Patches
 associated with Faces whose Edges were redone will be removed.
parms 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.



API -- Tessellation



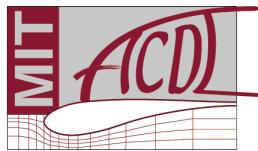
- **mapTessBody**

```
icode = EG_mapTessBody(ego tess, ego body, ego *mapTess)
icode = IG_mapTessBody(I*8 tess, I*8 body, I*8 mapTess)
```

Maps the input discretization object to another BODY Object. The topologies of the BODY that created the input tessellation must match the topology of the body argument (the use of `EG_mapBody` can be used to assist).

tess	the input BODY TESSELLATION object
body	the BODY object (with a matching Topology) used to map the tessellation.
mapTess	the resultant TESSELLATION object. The triangulation is simply copied but the <i>uv</i> and <i>xyz</i> positions reflect the input body (above).

Note: Invoking `EG_moveEdgeVert`, `EG_deleteEdgeVert` and/or `EG_insertEdgeVerts` in the source tessellation before calling this routine invalidates the ability of `EG_mapTessBody` to perform its function.



API -- Tessellation

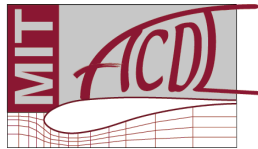


- **locateTessBody**

```
icode = EG_locateTessBody(ego tess, int npts, int *ifaces,  
                          double *uvs, int *itris, double *results)  
icode = IG_locateTessBody(I*8 tess, I*4 npts, I*4 ifaces,  
                          R*8      uvs, I*4 itris, R*8      results)
```

Provides the triangle and the vertex weights for each of the input requests or the evaluated positions in a mapped tessellation

tess the input BODY TESSELLATION object
npts the number of input requests
ifaces the face indices for each request – minus index refers to the use of a mapped Face index from **EG_mapBody** and **EG_mapTessBody** (npts in length)
uvs the UV positions in the face for each request (2*npts in length)
itris the resultant 1-bias triangle index (npts in length)
 if input as NULL then this function will perform mapped evaluations
results the vertex weights in the triangle that refer to the requested position (any negative weight indicates that the point was extrapolated) -or- the evaluated position based on the input uvs (when itris is NULL) (3*npts in length)



API -- Tessellation

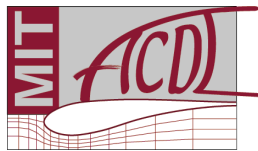


- **getTessEdge**

```
icode = EG_getTessEdge(ego tess, int eIndex, int *len,  
                      double **pxyz, double **pt)  
icode = IG_getTessEdge(I*8 tess, I*4 eIndex, I*4 len,  
                      CPTR      pxyz, CPRT      pt)
```

Retrieves the data associated with the discretization of an EDGE from a Body-based Tessellation Object.

tess the TESSELLATION object
eIndex the EDGE index (1 bias). The EDGE Objects and number of EDGES can be retrieved via `EG_getBodyTopos` and/or `EG_indexBodyTopo`. A minus refers to the use of a mapped (+) Edge index from applying the functions `EG_mapBody` and `EG_mapTessBody`.
len the returned number of vertices in the EDGE discretization
pxyz the returned pointer to the set of coordinate data.
pt the returned pointer to the parameter values associated with each vertex.



API -- Tessellation

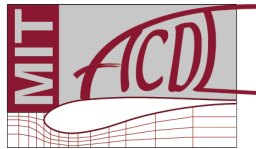


- **getTessFace**

```
icode = EG_getTessFace(ego tess, int fIndex, int *len, double **pxyz,  
                      double **puv, int **ptype, int **pindex,  
                      int *ntri, int **ptris, int **ptric)  
icode = IG_getTessFace(I*8 tess, I*4 fIndex, I*4 len, CPTR      pxyz,  
                      CPRT      puv, CPRT  ptype, CPRT  pindex,  
                      I*4 ntri, CPTR ptris, CPRT ptric)
```

Retrieves the data associated with the discretization of a FACE from a Body-based Tessellation Object.

tess	the TESSELLATION object
fIndex	the FACE index (1 bias). The FACE Objects and number of FACES can be retrieved via <code>EG_getBodyTopos</code> and/or <code>EG_indexBody</code> . A minus refers to the use of a mapped (+) Face index (if it exists).
len	the returned number of vertices in the triangulation
pxyz	the returned pointer to the set of coordinate data for each vertex
puv	returned pointer to the parameter values associated with each vertex
ptype	returned pointer to the vertex type (-1 - internal, 0 - NODE, >0 EDGE)
pindex	returned pointer to vertex index (-1 internal)
ntri	returned number of triangles
ptris	returned pointer to triangle indices (1 bias)
ptric	returned pointer to neighbor information



API -- Tessellation

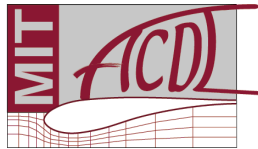


- **getTessQuads**

```
icode = EG_getTessQuads(ego tess, int *len, int **pindices)  
icode = IG_getTessQuads(I*8 tess, I*4 len, CPTR pindices)
```

Returns a list of FACE indices found in the Body-based Tessellation Object that has been successfully *Quadded*.

tess the TESSELLATION object
len the returned number of FACES with Quad patches
pindices the returned pointer the FACE indices (1 bias). The FACE Objects themselves can be retrieved via **getBodyTopos**. This pointer is *freeable*.



API -- Tessellation



- **makeQuads**

```
icode = EG_makeQuads(ego tess, double *parms, int fIndex)
icode = IG_makeQuads(I*8 tess, R*8 parms, I*4 fIndex)
```

Creates Quadrilateral Patches for the indicated FACE and updates the Body-based Tessellation Object.

tess the TESSELLATION object

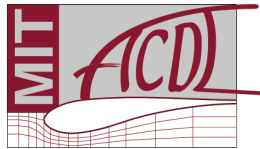
parms a set of 3 parameters that drive the Quadrilateral patching for the FACE. Any may be set to zero to indicate the use of the default value:

parms[0] EDGE matching tolerance expressed as the deviation from an aligned dot product [default: 0.05]

parms[1] Maximum quad *side* ratio point count to allow [default: 3.0]

parms[2] Number of smoothing loops [default: 0.0]

fIndex the FACE index (1 bias)



API -- Tessellation

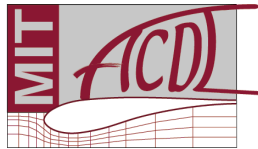


- **getQuads**

```
icode = EG_getQuads(ego tess, int fIndex, int *len,  
                   double **pxyz, double **puv, int **ptype,  
                   int **pindex, int *npatch)  
icode = IG_getQuads(I*8 tess, I*4 fIndex, I*4 len,  
                   CPTR    pxyz, CPRT    puv, CPRT    ptype,  
                   CPRT    pindex, I*4 npatch)
```

Retrieves the data associated with the Quad-patching of a FACE from a Body-based Tessellation Object.

tess the TESSELLATION object
fIndex the FACE index (1 bias). The FACE Objects and number of FACES
 can be retrieved via **getBodyTopos**.
len the returned number of vertices in the patching
pxyz the returned pointer to the set of coordinate data for each vertex
puv returned pointer to the parameter values associated with each vertex
ptype returned pointer to the vertex type (-1 - internal, 0 - NODE, >0 EDGE)
pindex returned pointer to vertex index (-1 internal)
npatch returned number of patches



API -- Tessellation

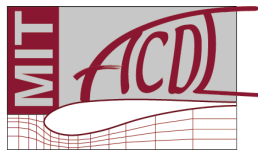


- **getPatch**

```
icode = EG_getPatch(ego tess, int fIndex, int pIndex, int *n1,  
                    int *n2, int **pvindex, int **pbounds)  
icode = IG_getPatch(I*8 tess, I*4 fIndex, I*4 pIndex, I*4 n1,  
                    I*4 n2, CPRT pvindex, CPRT pbounds)
```

Retrieves the data associated with the Patch of a FACE from a Body-based Tessellation Object.

tess the TESSELLATION object
fIndex the FACE index (1 bias). The FACE Objects and number of FACES can be retrieved via **getBodyTopos**.
pIndex the patch index (**1-npatch** from **EG_getQuads**)
n1 the returned patch size in the first direction (indexed by *i*)
n2 the returned patch size in the second direction (indexed by *j*)
pvindex the returned pointer to *n1*n2* indices that define the patch
pbounds returned pointer to the neighbor bounding information for the patch ($2*(n1-1)+2*(n2-1)$ in length). The first represents the segments at the base (*j* at base and increasing in *i*), the next is at the right (with *i* at max and *j* increasing). The third is the top (with *j* at max and *i* decreasing) and finally the left (*i* at min and *j* decreasing).



API -- Tessellation



- **moveEdgeVert**

```
icode = EG_moveEdgeVert(ego tess, int eIndex, int vIndex, double t)
icode = IG_moveEdgeVert(I*8 tess, I*4 eIndex, I*4 vIndex, R*8 t)
```

Moves the position of an EDGE vertex in a Body-based Tessellation Object. Will invalidate the *Quad* patches on any FACES touching the EDGE.

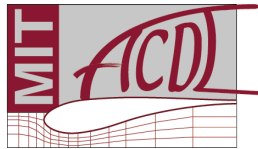
tess	the TESSELLATION object (not on WIREBODIES)
eIndex	the EDGE index (1 bias).
vIndex	the Vertex index in the EDGE (2 - nVert-1)
t	the new parameter value on the EDGE for the point

- **deleteEdgeVert**

```
icode = EG_deleteEdgeVert(ego tess, int eIndex, int vIndex, int dir)
icode = IG_deleteEdgeVert(I*8 tess, I*4 eIndex, I*4 vIndex, I*4 dir)
```

Deletes an EDGE vertex from a Body-based Tessellation Object. Will invalidate the *Quad* patches on any FACES touching the EDGE.

tess	the TESSELLATION object (not on WIREBODIES)
eIndex	the EDGE index (1 bias).
vIndex	the Vertex index in the EDGE to delete (2 - nVert-1)
dir	the direction to collapse any triangles (either -1 or 1)



API -- Tessellation

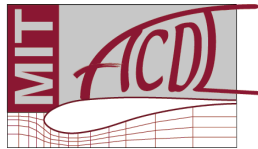


- **insertEdgeVerts**

```
icode = EG_insertEdgeVerts(ego tess, int eIndex, int vIndex,  
                           int len, double *ts)  
icode = IG_insertEdgeVerts(I*8 tess, I*4 eIndex, I*4 vIndex,  
                           I*4 len, R*8      ts)
```

Inserts vertices into the EDGE discretization of a Body-based Tessellation Object. This will invalidate the *Quad* patches on any FACES touching the EDGE.

tess	the TESSELLATION object (not on WIREBODIES)
eIndex	the EDGE index (1 bias).
vIndex	the Vertex index in the EDGE to insert the points after (1 - nVert-1)
len	the number of points to insert
ts	the <i>t</i> values for the new points. Must be monotonically increasing and be greater than the <i>t</i> of vIndex and less than the <i>t</i> of vIndex+1.



API -- High-Level Functions



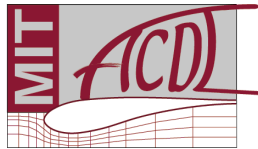
- **solidBoolean**

```
icode = EG_solidBoolean(ego src, ego tool, int oper,  
                        ego *model)  
icode = IG_solidBoolean(I*8 src, I*8 tool, I*4 oper,  
                        I*8 model)
```

Performs the Solid Boolean Operations (SBOs) on the source BODY Object (that has the type SOLIDBODY). The tool object types depend on the operation. This supports Intersection, Subtraction and Union.

src	the source SOLIDBODY object
tool	the tool object: either a SOLIDBODY for all operators -or- a FACE/FACEBODY for Subtraction
oper	1-Subtraction, 2-Intersection and 3-Fusion
model	the resultant MODEL object (this is because there may be multiple bodies from either the subtraction or intersection operation).

Note: This may be called with *src* being a MODEL. In this case *tool* may be a SOLIDBODY for Intersection or a FACE/FACEBODY for Fusion. The input MODEL may contain anything, but must not have duplicate topology.



API -- High-Level Functions



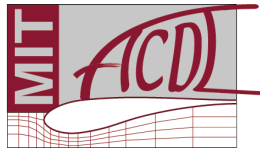
- **intersection**

```
icode = EG_intersection(ego src, ego tool, int *nEdge,  
                        ego **pFacEdg, ego *model)  
icode = IG_intersection(I*8 src, I*8 tool, I*4 nEdge,  
                        CPTR pFacEdg, I*8 model)
```

Intersects the source BODY Object (that has the type SOLIDBODY, SHEETBODY or FACEBODY) with a surface or surfaces. The tool object contains the intersecting geometry in the form of a FACEBODY, SHEETBODY, SOLIDBODY or a single FACE.

src the source BODY object
tool the FACE/FACEBODY/SHEETBODY/SOLIDBODY tool object
nEdge the number of EDGE objects created
pFacEdg pointer to FACE/EDGE object pairs - 2*nEdge in len (*freeable*)
 can be NULL (if you don't need this data - the EDGES are in **model**)
model the resultant MODEL object which contains the set of WIREBODY
 BODY objects (this is because there may be multiple LOOPS as
 a result of the operation).

NOTE: The EDGE objects contained within the LOOPS have the attributes of the FACE in **src** responsible for that EDGE.



API -- High-Level Functions

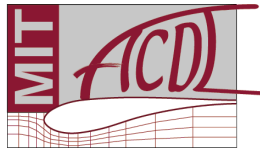


- **imprintBody**

```
icode = EG_imprintBody(ego src, int nEdge,  
                       ego *facEdg, ego *result)  
icode = IG_imprintBody(I*8 src, I*4 nEdge,  
                       I*8 facEdg, I*8 result)
```

Imprints EDGES on the source BODY Object (that has the type SOLIDBODY, SHEETBODY or FACEBODY). The EDGES are paired with the FACES in the source that will be scribed with the EDGE.

src	the source BODY object
nEdge	the number of EDGE objects to imprint
facEdg	list of FACE/EDGE object pairs to scribe - 2*nEdge in len can be the output from intersect
result	the resultant BODY object (with the same type as the input source object)



API -- High-Level Functions

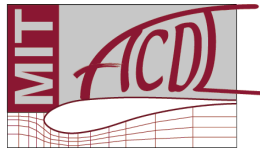


- **filletBody**

```
icode = EG_filletBody(ego src, int nEdge, ego *edges,  
                      double radius, ego *result, int **maps)  
icode = IG_filletBody(I*8 src, I*4 nEdge, I*8 edges,  
                      R*8 radius, I*8 result, CPTR maps)
```

Fillets the EDGES on the source BODY Object (that has the type SOLIDBODY or SHEETBODY).

src	the source BODY object
nEdge	the number of EDGE objects to fillet
edges	list of EDGE objects to fillet – nEdge in len
radius	the radius of the fillets created
result	the resultant BODY object (with the same type as the input source object)
maps	list of Face mappings (in the result) which includes operations and an index to <i>src</i> where the Face originated – 2*nFaces in result in length (<i>freeable</i>)



API -- High-Level Functions

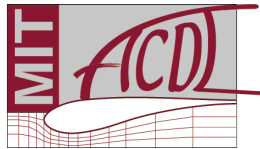


- **chamferBody**

```
icode = EG_chamferBody(ego src, int nEdge, ego *edges,  
                       ego *faces, double dis1,  
                       double dis2, ego *result, int **maps)  
icode = IG_chamferBody(I*8 src, I*4 nEdge, I*8 edges,  
                       I*8 faces, R*8 dis1,  
                       R*8 dis2, I*8 result, CPTR maps)
```

Chamfers the EDGES on the source BODY Object (that has the type SOLIDBODY or SHEETBODY).

src	the source BODY object
nEdge	the number of EDGE objects to chamfer
edges	list of EDGE objects to chamfer - nEdge in len
faces	list of FACE objects to measure <code>dis1</code> from - nEdge in len
dis1	the distance from the FACE object to chamfer
dis2	the distance from the other FACE to chamfer
result	the resultant BODY object (with the same type as the input source object)
maps	list of Face mappings (in the result) which includes operations and an index to <code>src</code> where the Face originated – 2*nFaces in result in length (<i>freeable</i>)



API -- High-Level Functions

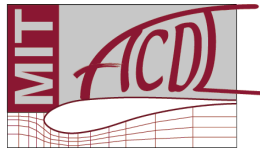


- **hollowBody**

```
icode = EG_hollowBody(ego src, int nFace, ego *faces,  
                      double off, int join, ego *result,  
                      int **maps)  
icode = IG_hollowBody(I*8 src, I*4 nFace, I*8 faces,  
                      R*8 off, I*4 join, I*8 result,  
                      CPTR maps)
```

A hollowed solid is built from an initial SOLIDBODY Object and a set of FACES that initially bound the solid. These FACES are removed and the remaining FACES become the walls of the hollowed solid with the specified thickness. If there are no FACES specified then the Body is offset by the specified distance (which can be negative).

src	the source BODY object
nFace	the number of FACE objects to remove (0 performs an Offset)
faces	list of FACE objects to remove - nFace in len
off	the wall thickness (offset) of the hollowed result
join	0 - fillet-like corners, 1 - expanded corners
result	the resultant SOLIDBODY object
maps	list of Face mappings (in the result) which includes operations and an index to src where the Face originated – 2*nFaces in result in length (<i>freeable</i>)



API -- High-Level Functions

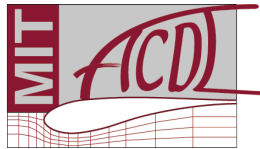


- **rotate**

```
icode = EG_rotate(ego src, double angle, double *axis,  
                  ego *result)  
icode = IG_rotate(I*8 src, R*8      angle, R*8      axis,  
                  I*8  result)
```

Rotates the source Object about the axis through the angle specified. If the Object is either a LOOP or WIREBODY the result is a SHEETBODY. If the source is either a FACE or FACEBODY then the returned Object is a SOLIDBODY.

src	the source Object
angle	the angle to rotate the object through [0-360 Degrees]
axis	a point (on the axis) and a direction (6 in length)
result	the resultant BODY object (type is one greater than the input source object)



API -- High-Level Functions

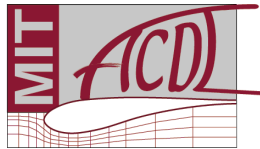


- **extrude**

```
icode = EG_extrude(ego src, double length, double *dir,  
                  ego *result)  
icode = IG_extrude(I*8 src, R*8 length, R*8 dir,  
                  I*8 result)
```

Extrudes the source Object through the distance specified. If the Object is either a LOOP or WIREBODY the result is a SHEETBODY. If the source is either a FACE or FACEBODY then the returned Object is a SOLIDBODY.

src	the source Object
length	the distance to extrude
dir	the vector that is the extrude direction (3 in length)
result	the resultant BODY object (type is one greater than the input source object)



API -- High-Level Functions



- **sweep**

```
icode = EG_sweep(ego src, ego spine, int mode, ego *result)
icode = IG_sweep(I*8 src, I*8 spine, I*4 mode, I*8 result)
```

Sweeps the source Object through the “spine” specified. The spine can be either an EDGE, LOOP or WIREBODY. If the source Object is either a LOOP or WIREBODY the result is a SHEETBODY. If the source is either a FACE or FACEBODY then the returned Object is a SOLIDBODY.

src the source Object

spine the Object used as *guide curve* segment(s) to sweep the source through

mode sweep mode:

0 - *CorrectedFrenet*

5 - *GuideAC*

1 - *Fixed*

6 - *GuidePlan*

2 - *Frenet*

7 - *GuideACWithContact*

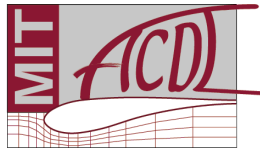
3 - *ConstantNormal*

8 - *GuidePlanWithContact*

4 - *Darboux*

9 - *DiscreteTrihedron*

result the resultant BODY object (type is one greater than the input source Object)



API -- High-Level Functions



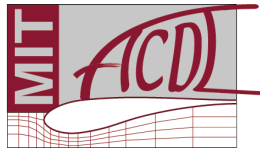
- **loft**

```
icode = EG_loft(int nSection, ego *sections,  
               int options,  ego *result)  
icode = IG_loft(I*4 nSection, I*8  sections,  
               I*4 options,  I*8  result)
```

Lofts the input Objects to create a BODY Object (that has the type SOLIDBODY or SHEETBODY).

nSection the number of Sections in the Loft Operation
sections list of WIREBODY or LOOP objects to Loft - nSection in len
the first and last can be NODEs
options bit flag that controls the loft:
1 - SOLIDBODY result (default is SHEETBODY)
2 - Ruled (linear) Loft (default is smooth)
result the resultant BODY object

Note: This function may be deprecated in the future. Please use either **EG_blend** or **EG_ruled**.



API -- High-Level Functions



- **blend**

```
icode = EG_blend(int nSection, ego *sections, double *rc1,  
                double *rcN, ego *result)  
icode = IG_blend(I*4 nSection, I*8 sections, R*8 rc1,  
                R*8 rcN, I*8 result)
```

Simply lofts the input Objects to create a BODY Object (that has the type SOLIDBODY or SHEETBODY). All sections must have the same number of Edges (except for NODEs) and the Edge order in each (defined in a CCW manner) is used to specify the loft connectivity.

nSection the number of Sections in the Blend Operation

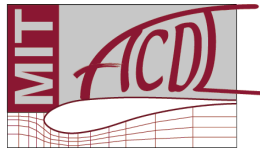
sections list of WIREBODY or LOOP objects to Blend - nSection in len
the first and last can be NODEs and/or FACEs (only one LOOP),
the orientation of FACE is used to complement the lofted surfaces,
if the first and last are NODEs and/or FACEs the result will be
a SOLIDBODY otherwise a SHEETBODY will be constructed

rc1 specifies treatment* at the first section (or NULL for no treatment)

rcN specifies treatment* at the last section (or NULL for no treatment)

result the resultant BODY object

* NODE -- elliptical treatment (8 in length): radius of curvature1, unit direction, rc2, orthogonal direction; other sections -- setting tangency (4 in length): magnitude, unit direction



API -- High-Level Functions



- **ruled**

```
icode = EG_ruled(int nSection, ego *sections, ego *result)
icode = IG_ruled(I*4 nSection, I*8 sections, I*8 result)
```

Produces a BODY Object (that has the type SOLIDBODY or SHEETBODY) that goes through the sections by ruled surfaces between each. All sections must have the same number of Edges (except for NODEs) and the Edge order in each is used to specify the connectivity.

nSection the number of Sections in the Ruled Operation

Sections A list of NODE, WIREBODY, LOOP and/or FACE objects to operate upon - nSection in len,

Any FACE objects must contain only a single LOOP,

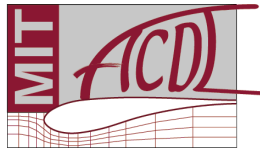
Only the first and last sections can be NODEs,

If the first and last sections are NODEs and/or FACES and all

WIREBODY and LOOP objects are closed, the result will be a SOLIDBODY otherwise a SHEETBODY will be constructed

result the resultant BODY object

Note: for both **blend** and **ruled** all Loops must have their Edges ordered in a counterclockwise manner.



API -- Return Codes



```
#define EGADS_ATTRERR -29
#define EGADS_TOPOCNT -28
#define EGADS_OCSEGFALT -27      /* OpenCASCADE Seg Fault */
#define EGADS_BADSCALE -26
#define EGADS_NOTORTHO -25
#define EGADS_DEGEN -24
#define EGADS_CONSTERR -23      /* construction error */
#define EGADS_TOPOERR -22
#define EGADS_GEOMERR -21
#define EGADS_NOTBODY -20
#define EGADS_WRITERR -19
#define EGADS_NOTMODEL -18
#define EGADS_NOLOAD -17
#define EGADS_RANGERR -16
#define EGADS_NOTGEOM -15
#define EGADS_NOTTESS -14
#define EGADS_EMPTY -13
#define EGADS_NOTTOPO -12
#define EGADS_REFERCE -11
#define EGADS_NOTXFORM -10
#define EGADS_NOTCNTX -9
#define EGADS_MIXCNTX -8
#define EGADS_NODATA -7
#define EGADS_NONAME -6
#define EGADS_INDEXERR -5
#define EGADS_MALLOCC -4
#define EGADS_NOTOBJ -3
#define EGADS_NULLOBJ -2
#define EGADS_NOTFOUND -1
#define EGADS_SUCCESS 0
#define EGADS_OUTSIDE 1      /* also -- not the same */
```

