```
}

Bool ArithmeticCodec::removeSymbolFromStream(
                           ArithmeticProbabilityRange& sym,
                           CodecDriver* pDriver)
{
   // First, the range is expanded to account for the symbol removal.
   UInt32 range = UInt32(high - low)  + 1;
   high = low + (UInt32)((range * sym.high_count) / sym.scale - 1);
   low  = low + (UInt32)((range * sym.low_count ) / sym.scale);

   //Next, any possible bits are shipped out.
   for (;;)
   {
      // If the most signif digits match, the bits will be shifted out.
      if( (~(high^low)) & 0x8000 )
      {
      }
      else if( (low & 0x4000) && !(high & 0x4000) )
      {
         // Underflow is threatening, shift out 2nd most signif digit.
         code ^= 0x4000;
         low  &= 0x3fff;
         high |= 0x4000;
      }
      else
      {
         // Nothing can be shifted out, so return.
         return True;
      }

      low  <<= 1;
      high <<= 1;
      high |=  1;
      code <<= 1;

      if( nBits == 0 )
      {
         // The returned nBits here will always be 32
         pDriver->getNextCodeText(bitBuffer, nBits);
      }

      code |= (UInt16)(bitBuffer >> 31);
      bitBuffer <<= 1;
      nBits--;
   }
}
```

C.5 Deering Normal decoding classes

T(e follo%ing s!0-sections contain a sam/le im/lementation of t(e eco ing /ortion of t(e Deering +ormal - , D . - algorit(m. ' s!mmar# tec(nical e>/lnation of t(e Deering +ormal - , D . - can 0e fo!n in 8.2.E Deering +ormal - , D . -.

C.5.1 DeeringNormalLookupTable class

T(e Deering+ormal"oo3!/Ta0le class re/resents a loo3!/ ta0le !se 0# t(e Deering+ormal-o ec class for faster conversion from t(e com/resse normal re/resentation to t(e stan ar B-float re/resentation. T(e ta0les (ol /recom/!te res!lts of t(e trig f!nctions calle !ring conversion.

```
class DeeringNormalLookupTable
{
public:
   DeeringNormalLookupTable();

   // Lookup and return the result of converting iTheta and iPsi to
   // real angles and taking the sine and cosine of both.  This gives
   // a slight speedup for normal decoding.
   Bool lookupThetaPsi(Int32 iTheta,
                       Int32 iPsi,
                       UInt32 numberBits,
                       Float32 outCosTheta,
                       Float32 outSinTheta,
                       Float32 outCosPsi,
                       Float32 outSinPsi );

   UInt32 numBitsPerAngle() {return nBits;}

private:
   UInt32 nBits;
   Vector vCosTheta;
   Vector vSinTheta;
   Vector vCosPsi;
   Vector vSinPsi;
};

DeeringNormalLookupTable::DeeringNormalLookupTable()
{
   UInt32 numberbits = 8;
   nBits = min(numberbits, (UInt32)31);

   Int32 tableSize = (1 << nBits);

   vCosTheta.setLength(tableSize+1);
   vSinTheta.setLength(tableSize+1);
   vCosPsi.setLength(tableSize+1);
   vSinPsi.setLength(tableSize+1);

   Float32 fPsiMax = 0.615479709;
```

```
   Float32 fTableSize = (Float32)tableSize;

   for( Int32 ii = 0; ii <= tableSize; ii++ )
   {
      Float32 fTheta =
         asin(tan(fPsiMax * Float32(tableSize - ii) / fTableSize));

      Float32 fPsi  = fPsiMax * (((Float32)ii) / fTableSize);
      vCosTheta[ii] = cos(fTheta);
      vSinTheta[ii] = sin(fTheta);
      vCosPsi[ii]   = cos(fPsi);
      vSinPsi[ii]   = sin(fPsi);
   }
}

Bool DeeringNormalLookupTable::lookupThetaPsi(Int32 iTheta,
                                              Int32 iPsi,
                                              UInt32 numberBits,
                                              Float32 outCosTheta,
                                              Float32 outSinTheta,
                                              Float32 outCosPsi,
                                              Float32 outSinPsi)
{
   Int32 offset = nBits - numberBits;

   outCosTheta = vCosTheta[iTheta << offset];
   outSinTheta = vSinTheta[iTheta << offset];
   outCosPsi   = vCosPsi[iPsi << offset];
   outSinPsi   = vSinPsi[iPsi << offset];

   return True;
}
```

C.5.2 DeeringNormalCodec class

T(e Deering+ormal-o ec class converts a normal vector to an from t(e stan ar B-float re/resentation an a lo%er-/recision re/resentation. T(e /recision can 0e a 7!ste !sing t(e n0its /arameter.

```
class DeeringNormalCodec
{
public:
   DeeringNormalCodec(Int32 numberbits = 6)
   {
      numBits = numberbits;
   }

   // Converts a compressed normal into a vector.
   Bool convertCodeToVec(UInt32 code, Vector& outVec);

   // Converts a compressed normal into a vector.
   Bool convertCodeToVec(UInt32 iSextant,
```

```
                          UInt32 iOctant,
                          UInt32 iTheta,
                          UInt32 iPsi,
                          Vector& outVec);

   // Separates an encoded normal into its 4 pieces
   Bool unpackCode(UInt32  code,
                   UInt32& outSextant,
                   UInt32& outOctant,
                   UInt32& outTheta,
                   UInt32& outPsi );

   private:
      Int32 numBits;
}

Bool DeeringNormalCodec::convertCodeToVec(UInt32 code, Vector& outVec)
{
   UInt32 s=0, o=0, t=0, p=0;
   unpackCode(code, s, o, t, p);

   convertCodeToVec(s, o, t, p, outVec);

   return True;
}

Bool DeeringNormalCode::convertCodeToVec(UInt32 iSextant,
                                         UInt32 iOctant,
                                         UInt32 iTheta,
                                         UInt32 iPsi,
                                         Vector& outVec)
{
   // Size of code = 6+2*numBits, and max code size is 32 bits,
   // so numBits must be <= 13.

   // Code layout: [sextant:3][octant:3][theta:numBits][psi:numBits]

   outVec.setValues(0,0,0);
   Float32 fPsiMax = 0.615479709;

   UInt32  iBitRange = 1<<numBits;
   Float32 fBitRange = Float32(iBitRange);

   // For sextants 1, 3, and 5, iTheta needs to be incremented
   iTheta += (iSextant & 1);

   Float32 fCosTheta, fSinTheta, fCosPsi, fSinPsi;

   DeeringNormalLookupTable LookupTable;

   if( (LookupTable.numBitsPerAngle() < (UInt32)numBits) ||
```

```
    !LookupTable.lookupThetaPsi(iTheta, iPsi, numBits,
                                fCosTheta, fSinTheta,
                                fCosPsi, fSinPsi) )
{
   Float32 fTheta = asin(tan(fPsiMax * Float32(iBitRange - iTheta) /
                             fBitRange));

   Float32 fPsi = fPsiMax * (iPsi / fBitRange);
   fCosTheta = cos(fTheta);
   fSinTheta = sin(fTheta);
   fCosPsi   = cos(fPsi);
   fSinPsi   = sin(fPsi);
}

Float32 x,y,z;
Float32 xx = x = fCosTheta * fCosPsi;
Float32 yy = y = fSinPsi;
Float32 zz = z = fSinTheta * fCosPsi;

//Change coordinates based on the sextant
switch( iSextant )
{
   case 0:     // No op
      break;

   case 1:     // Mirror about x=z plane
      z = xx;
      x = zz;
      break;

   case 2:     // Rotate CW
      z = xx;
      x = yy;
      y = zz;
      break;

   case 3:     // Mirror about x=y plane
      y = xx;
      x = yy;
      break;

   case 4:     // Rotate CCW
      y = xx;
      z = yy;
      x = zz;
      break;

   case 5:     // Mirror about y=z plane
      z = yy;
      y = zz;
      break;
```

```
   };

   //Change some more based on the octant

   //if first bit is 0, negate x component
   if( !(iOctant & 0x4) )
      x = -x;

   //if second bit is 0, negate y component
   if( !(iOctant & 0x2) )
      y = -y;

   //if third bit is 0, negate z component
   if( !(iOctant & 0x1) )
      z = -z;

   outVec.setValues(x,y,z);

   return True;
}

Bool DeeringNormalCodec::unpackCode(UInt32 code,
                                    UInt32& outSextant,
                                    UInt32& outOctant,
                                    UInt32& outTheta,
                                    UInt32& outPsi)
{
   UInt32 mask = (1<<numBits)-1;

   outSextant = (code >> (numBits+numBits+3)) & 0x7;
   outOctant  = (code >> (numBits+numBits))   & 0x7;
   outTheta   = (code >> (numBits))           & mask;
   outPsi     = (code)                        & mask;

   return True;
}
```

Appendix D: Parasolid XT Format Reference

+ovem0er 2008

Table of Contents

Introduction to the Parasolid XT Format

T(is Parasoli O Transmit File Format man!al escri0es t(e formats in %(ic(Parasoli re/resents mo el information in e>ternal files. Parasoli is a geometric mo eling 3ernel t(at can re/resent %ireframe) s!rface) soli) cell!lar an general non-manifol mo els.

Parasoli stores to/ological an geometric information efining t(e s(a/e of mo els in transmit files. T(ese files (ave a /!0lis(e format so t(at a//lications can (ave access to Parasoli mo els %it(o!t necessaril# !sing t(e Parasoli 3ernel.

T(is man!al oc!ments t(e Parasoli transmit file format. T(is format %ill c(ange in s!0seA!ent Parasoli releases at %(ic(time t(is man!al %ill 0e !/ ate . 's ne% versions of Parasoli can rea an %rite ol er transmit file formats t(ese c(anges %ill not invali ate a//lications %ritten 0ase on t(e information (erein.

Types of File Documented

T(ere are a n!m0er of ifferent interface ro!tines in Parasoli for %riting transmit files. .ac(of t(ese ro!tines can %rite slig(tl# ifferent com0inations of Parasoli ata) t(e ones t(at are oc!mente (erein are*

- &n ivi !al com/onents 1or assem0lies2 %ritten !sing S ' V $, D
- &n ivi !al com/onents %ritten !sing P<VP ' RTVtransmit
- "ists of com/onents %ritten !sing P<VP ' RTVtransmit
- Partitions %ritten !sing P<VP ' RT&T&, +Vtransmit

T(e 0asic format !se to %rite ata in all t(e a0ove cases is i entical? t(ere are a small n!m0er of no e t#/es t(at are s/ecific to eac(of t(e a0ove file t#/es.

Text and Binary Formats

Parasoli can enco e t(e ata it %rites o!t in fo!r ifferent formats*

1. Te>t 1!s!all# 'S-&&2
2. +e!tral 0inar#
B. :are 0inar# 1t(is is not recommen e 2
D. T#/e 0inar#

&n te>t format all t(e ata is %ritten o!t as (!man rea a0le te>t) t(e# (ave t(e a vantage t(at t(e# are rea a0le 0!t t(e# also (ave a n!m0er of isa vantages. T(e# are relativel# slo% to rea an %rite) converting to an from te>t forms of real n!m0ers intro !ces ro!n ing errors t(at can 1in e>treme cases2 ca!se /ro0lems an finall# t(ere are limitations %(en ealing %it(m!lti-0#te c(aracter sets. -arriage ret!rn or line fee c(aracters can a//ear an#%(ere in a te>t transmit file 0!t ot(er !ne>/ecte non-/rinting c(aracters %ill ca!se Parasoli to re7ect t(e file as corr!/t.

+e!tral 0inar# is a mac(ine in e/en ent 0inar# format.

:are 0inar# is a mac(ine e/en ent 0inar# format. &t is not a recommen e format since t(e mac(ine t#/e %(ic(%rote it m!st 0e 3no%n 0efore it can 0e inter/rete .

T#/e 0inar# is a mac(ine e/en ent 0inar# format) 0!t it (as a mac(ine in e/en ent /refi> escri0ing t(e mac(ine t#/e t(at %rote it an so can 0e rea on all mac(ine t#/es.

Standard File Names and Extensions

D!e to c(anging o/eration s#stem restrictions on file names over t(e #ears Parasoli (as !se several ifferent file e>tensions to enote file contents. T(e recommen e set of file e>tensions is*

- .8VT an .8V: for /art files) .PVT an .PV: for /artition files.

.>tensions t(at (ave 0een !se in t(e /ast are*

- >mtVt>t) >m/Vt>t - te>t format files on V$S or 4ni> /latforms
- >mtV0in) >m/V0in - 0inar# format files on V$S or 4ni> /latforms

Logical Layout

T(e logical la#o!t of a Parasoli transmit file is*

- ' (!man-oriente te>t (ea er.
  - T(e initial te>t (ea er is rea an %ritten 0# a//lications¡ Fr!str!ms an is not accessi0le to Parasoli . &ts etaile format is escri0e in t(e section hP(#sical la#o!t¡.
- ' s(ort flag seA!ence escri0ing t(e file format) follo%e 0# mo eller i entification information an !ser fiel siHe.
  - T(e vario!s flag seA!ences 1mi>t!res of te>t an n!m0ers2 are oc!mente !n er hP(#sical la#o!t¡? t(e content of t(e mo eller i entification information is*

    t(e mo eller version !se to %rite t(e file) as a te>t string of t(e form*

    * TR ' +S $ &T F&" . create 0# mo eller version 120012B

    T(is information is !se 0# ro!tines s!c(as P<VP ' RTVas3V3ernelVversion.

    t(e sc(ema version escri0ing t(e fiel seA!ences of t(e /art no es as a te>t string of t(e form*

    S- ;V120012BV1200F

    T(is e>am/le enotes a file %ritten 0# Parasoli V12.0.12B !sing sc(ema n!m0er 1200F* t(ere %ill 0e a corres/on ing file sc(V1200F in t(e Parasoli sc(ema istri0!tion.

    +ote t(at a//lications %riting 8T files s(o!l !se version 1200000 an sc(ema n!m0er 1200F.

  - T(e !ser fiel siHe is a sim/le integer.
- T(e o07ects 13no%n as Uno esN2 in t(e file in an !nor ere seA!ence) follo%e 0# a terminator.
  - .ver# no e in t(e file is assigne an integer in e> from 1 !/%ar s 1some in ices ma# not 0e !se 2. Pointer fiel s are o!t/!t as t(ese in ices) or as Hero for a n!ll /ointer.
  - .ac(no e entr# 0egins %it(t(e no e t#/e. &f t(e no e is of varia0le lengt(1see 0elo%2) t(is is follo%e 0# t(e lengt(of t(e varia0le fiel . T(e in e> of t(e no e is t(en o!t/!t) follo%e 0# t(e fiel s of t(e no e. &f t(e file contains !ser fiel s) an t(e no e is visi0le at t(e P< interface) t(en t(e fiel s are follo%e 0# t(e !ser fiel) in integers.
  - T(e terminator %(ic(follo%s t(e seA!ence of no es is a t%o-0#te integer %it(val!e 1) follo%e 0# an in e> %it(val!e 0. T(e in e> is o!t/!t as UON in a te>t file) an as a 2-0#te integer %it(val!e 1 in a 0inar# file.
  - T(e no e %it(in e> 1 is t(e root no e of t(e transmit file as follo%s*
  -

Contents o> >i"e	Ty$e o> root node

:o #	:,D9
'ssem0l#	'SS.$:"9
'rra# of /arts	P,&+T.RV"&SV:",-<
Partition	=,R"D

Schema

Parasoli /ermanent str!ct!res are efine in a s/ecial lang!age a3in to - %(ic(generates t(e a//ro/riate files for a - com/iler) t(e r!ntime information !se 0# Parasoli) along %it(a sc(ema file !se !ring transmit an receive. T(e sc(ema file for version 12.0 is name sc(V1200F an is istri0!te %it(Parasoli .&t is not necessar# to (ave a co/# of t(is file to !n erstan t(e 8T format.

For eac(no e t#/e) t(e sc(ema file (as a no e s/ecifier of t(e form

Yno et#/eZ Yno enameZ? Y escri/tionZ? Ytransmit 150Z Yno. of fiel sZ Yvaria0le 150Z

e.g.

29 P , &+T? Point? 1 F 0

T(is is follo%e 0# a list of fiel s/ecifiers %(ic(sa# %(at fiel s) an in %(at or er) occ!r in t(e transmit file.

Fiel s/ecifiers (ave t(e format*

Yfiel nameZ? Yt#/eZ? Ytransmit 150Z Yno e classZ YnVelementsZ

e.g.

o%ner? /? 1 1011 1

+o es an fiel s %it(a transmit flag of Hero are e/(emeral information not %ritten to a transmit file. , nl# /ointer fiel s (ave non-Hero no e class) in %(ic(case it s/ecifies t(e set of no e t#/es to %(ic(t(is fiel is allo%e to /oint. T(e element co!nt is inter/rete as follo%s*

0	a scalar) a single val!e
1	a varia0le lengt(fiel 1see 0elo%2
n Z 1	an arra# of n val!es

+ote t(at in t(e sc(ema file) fins are referre to as U(alfe gesN) an gro!/s are referre to as Ufeat!resN. T(ese are internal names not !se else%(ere in t(is oc!ment.

Embedded schemas

= (en rea ing a /art) /artition) or elta) Parasoli converts an# ata t(at it enco!nters from ol er versions of Parasoli to t(e c!rrent format !sing a mi>t!re of a!tomatic ta0le conversion 1 riven 0# t(e a//ro/riate sc(emas2) an e>/licit co e for more com/le> algorit(ms.

; o%ever) 0ac3%ar s com/ati0ilit# of file information Q t(at is) rea ing ata create 0# a ne%er version of Parasoli into an a//lication 1s!c(as ata create 0# a s!0contractor2 Q can never 0e g!arantee to %or3 !sing t(is met(o) 0eca!se t(e ol er version oes not contain an# s/ecial-case conversion co e.

From Parasoli V1D on%ar s) /arts) /artitions an eltas can 0e transmitte %it(e>tra information t(at is inten e to re/lace t(e sc(ema normall# loa e to escri0e t(e ata la#o!t. T(is information contains t(e di>>eren#es 0et%een its sc(ema an a efine 0ase sc(ema 1c!rrentl# V1B%s S- ; V1B00F2.

T(is ena0les /arts) /artitions) an eltas to 0e s!ccessf!ll# rea into ol er versions of Parasoli %it(o!t loss of information.

T(e onl# fiel s t(at are incl! e in t(is information are t(ose %(ic(can 0e reference in a c!t-o%n version of t(e sc(ema /ertaining onl# to t(e 8T /art ata t(at is transmitte . S/ecificall#) a f!ll sc(ema efinition can contain fiel s t(at are not relevant in t(e conte>t of t(e transmitte ata 1fiel s relating to sna/s(ots) for e>am/le2) an t(ese fiel s are e>cl! e .

Fiel s t(at are incl! e are referre to as e>>e#tive >ie"ds) an are eit(er transmitta0le `xmt_code` [[12 or (ave varia0le-lengt(`n_elts` [[12

Physical layout

$ ost of t(e ata are com/ose of integers) logical flags) an strings) 0!t are of restricte ranges an so transmitte s/eciall# in 0inar# format. T(e 0inar# re/resentation is given in 2o"d t#/e) s!c(as Iinteger 12yte2K. T(is is relevant to a//lications t(at attem/t to rea or %rite Parasoli ata irectl#. T%o im/ortant elements are

- short strin s

  T(ese are transmitte as an integer lengt(12yte2 follo%e 0# t(e c(aracters 1%it(o!t trailing Hero2.

- $ositive inte ers

  T(ese are transmitte similarl# to t(e /ointer in ices %(ic(lin3 in ivi !al o0[illegible]

`type`	s(ort string	T(e fiel t#/e. ' llo%e val!es are escri0e in IFiel t#/esK) 0elo%. , mitte if `ptr_class` non-Hero
`xmt_code`	logical 10#te2	, mitte for fi>e -lengt(`1n_elts _[ 12`

- &f t(e t%o arra#s matc(1eA!al lengt(an all fiel s matc(in `name`) `xmtVcode`) `ptr_class`) `n_elts` an `type`2 t(en o!t/!t t(e flag val!e 2EE 12yte 0>ff2.
- &f t(e t%o arra#s o not matc() o!t/!t t(e n!m0er of effective fiel s in t(e c!rrent sc(ema 12yte2) an an e it seA!ence as follo%s.
  - &nitialiHe /ointers to t(e first 0ase fiel an first c!rrent fiel) t(en %(ile t(ere are still !n/rocesse 0ase an c!rrent fiel s) o!t/!t a seA!ence of -o/#) Delete an &nsert instr!ctions
    - &f t(e 0ase fiel matc(es t(e c!rrent fiel) o!t/!t @-@ 1#har2 to in icate an !nc(ange 1-o/ie 2 fiel an a vance to t(e ne>t 0ase an c!rrent fiel s?
    - &f t(e 0ase fiel oes not matc(an# !n/rocesse c!rrent fiel) o!t/!t @D@ 1#har2 to in icate a Delete fiel an a vance to t(e ne>t 0ase fiel ?
    - , t(er%ise) o!t/!t @&@ 1#har2 to in icate an &nserte fiel) follo%e 0# t(e c!rrent fiel in t(e a0ove format) an a vance to t(e ne>t c!rrent fiel .
  - &f t(ere are an# !n/rocesse c!rrent fiel s) t(en o!t/!t an ' //en seA!ence) eac(instr!ction 0eing @ ' @ 1#har2 follo%e 0# t(e fiel .
- Finall#) o!t/!t @L@ 1#har2 to signal t(e en .

Space compression

For te>t ata in transmit formats P<VtransmitVformatVte>tVc an P<VtransmitVformatV>mlVc) a ne% esca/e seA!ence is efine *t(e 2-c(aracter seA!ence W' enotes a seA!ence of nine s/aces. ' t V1D) t(is a//lies to attri0!te efinition names) fiel names) an attri0!te strings.

Field types

T(e 8T format is not itself a 0inar# /rotocol) an so oes not efine ata siHes? t(e onl# reA!irement is t(at a r!ntime im/lementation (as s!fficient room for t(e information. T(e availa0le im/lementations r!n %it(80it ' S-&& c(aracters) 80it !nsigne 0#tes 10..2EE2) 1F0it s(ort integers 10..FEEBE or -B2CF8..B2CFC2) B20it integers 10..D6-1) -26..26-12 an &... reals. T(e im/lementation !se in a given 0inar# file is s/ecifie 0# t(e bPSYco eZb at t(e start of t(e file. See t(e c(a/ter on IP(#sical "a#o!tK for more information.

T(e f!ll list of fiel t#/es !se in transmit files is as follo%s*

! !nsigne 0#te 0-2EE

c c(ar

l !nsigne 0#te 0-1 1i.e. logical2

typedef char logical;

n s

```
      vector                          /vec?                          55 iv
      X?
t#/e  ef str!ct P , &+TVs          ]P , &+T?
```

&ts corres/on ing sc(ema file entr# is

```
29 P , &+T? Point? 1 F 0
no eVi ? ? 1 0 0
attri0!tesVgro!/s? /? 1 1019 0
o%ner? /? 1 1011 0
ne>t? /? 1 29 0
/revio!s? /? 1 29 0
/vec? v? 1 0 0
```

Pointer classes

&n t(e a0ove e>am/le) t(e attri0!tesVgro!/s fiel m!st 0e of class 'TTR&:V6R , 4PVcl) t(e o%ner m!st 0e of class P , &+TV , = + . RVcl) an t(e ne>t an /revio!s fiel s m!st refer to P , &+Ts. ' f!ll list of no e t#/es an no e classes is given at t(e en of t(e oc!ment.

. ac(no e class corres/on s to a !nion of /ointers given in t(e Sc(ema Definition section.

Variable-length nodes

Varia0le-lengt(no es iffer from fi>e -lengt(no es in t(at t(eir last fiel is of varia0le lengt() i.e. ifferent no es of t(e same t#/e ma# (ave ifferent lengt(s. &n t(e sc(ema t(e lengt(is notionall# given as 1) e.g.

```
str!ct R . '"VV'"4 . SVs          55 Real val!es
      W
      Do!0le                          val!esR1S?                     55 ifRS
      };
```

&ts sc(ema file entr# %o!l 0e

```
8B R . '"VV'"4 . S?    Real val!es? 1 1 1
val!es? f? 1 0 1
```

T(e n!m0er of entries in eac(s!c(no e is in icate 0# an integer in t(e transmit file 0et%een its no et#/e an in e>) so an e>am/le mig(t 0e

8B B 1E 1 2 B

Unresolved indices

&n some cases a no e %ill contain an in e> fiel %(ic(oes not corres/on to a no e in t(e transmit file) in t(is case t(e in e> is to 0e inter/rete as Hero.

Simple example

; ere is a reformatte te>t e>am/le of a s(eet circle %it(a color attri0!te on its single e ge*

```
]] ' : - D . F6 ; &J < " $ + , PGRST 4 V = 8 9 La0c efg(i73lmno/Arst!v%>#H]]]]]]]]]]]
]]P ' R ' S , "&D _bJ i c T@12] \)-.5*?Y [ Zd j R^SkVhWaX`012BDEFC89]]]]]]]]]]]
]]P ' RT1? $ - [ osfFE? $ - V $ , D . " [ al/(a? $ - V&D [ s losfF? , S [ , SF1? , SVR . " . ' S . [ VD.0?FR
4 [ s lV/arasoli VtestVosfFD? ' PP" [ !n3no%n?S&T . [ s l-cam0ri ge-
!.3.?4 S . R [ avi 7?F , R $ ' T [ te>t? 6 4&S . [ transmit?D ' T . [ 29-mar-2000?
]]P ' RT2?S - ; [ S - ; V1200000V1200F? 4 SF" DVS&L . [ 0?
]]P ' RTB?
]] . +DV , FV ; . ' D . R]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]]
TE1 * TR ' +S $ &T F&" . create 0# mo eller version 12000001C S - ; V1200000V1200F0
12 1 12 0 2 0 0 0 0 1eB 1e-8 0 0 0 1 0 B 1 B D E 0 F C 0        0o #
C0 2 0 1 0 0 D 1 20 8 8 8 1 T                                 list
1B B B 0 1 0 9 0 0 F 9                                        s(ell
E0 D 11 0 9 0 0 0 \ 0 0 0 0 0 1 1 0 0                         /lane
B1 E 10 0 C 0 0 0 \ 0 0 0 0 0 1 1 0 0 1                       circle
19 F E 0 1 0 0 B V                                            region
1F C F 0 d10 0 0 E 0 0 1                                      e ge
1C 10 0 11 10 10 0 12 C 0 0 \                                 fin
1E 11 C 0 10 9 0                                              loo/
1C 12 0 0 0 0 0 10 C 0 0 -                                    fin 1 !mm#2
1D 9 2 1B d0 0 11 B D \ 0 0 0 0 B                             face
81 1 1B 12 1D 9 0 0 0 0 1E                                    attri0!te 1varia0le 12
80 1 1D 0 1F 8001 0 0 0 0 B E 0 0 FFFFTFTFFFFFF2              attri0V ef 1varia0le 12
8B B 1E 1 2 B                                                 realVval!es 1varia0le B2
C9 1E 1F SD"5T9S ' V- , " , 4R                                attV efVi 1varia0le 1E2
CD 20 8 1 0 1B 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0        /ointerVlisV0loc3
```

1 0 terminator

+ote t(at t(e tolerance fiel s of t(e face an e ge are !nset) an re/resente as UdN in t(e te>t transmit file an t(at t(e annotations in t(e col!mn U0o #N to UterminatorN give t(e no e t#/e of eac(line an are not /art of t(e act!al file. &f t(e a0ove file (a no trailing s/aces) it %o!l 0e a vali 8T file 1t(e lea ing s/aces on some of t(e lines are necessar#2.

Physical Layout

Parasoli transmit files (ave t%o (ea ers*

- a te>t!al intro !ction containing (!man- irecte information a0o!t t(e /art) %ritten 0# t(e Fr!str!m an not accessi0le to Parasoli) an
- an internal /refi> to t(e /art ata) escri0ing to Parasoli t(e format of t(e /art ata an t(!s not seen e>/licitl# 0# an a//lication's Fr!str!m.

Common header

T(e Parasoli common (ea er recommen e to Fr!str!m %riters consists of*

- ' /ream0le containing all c(aracters in t(e 'S-&& /rinting set. T(is is !se 0# t(e <&D Fr!str!m to etect o0vio!s net%or3 corr!/tion) 0!t co!l 0e !se to attem/t to translate a te>t file from one c(aracter set to anot(er.
- Part 1 ata* a seA!ence of 3e#%or -val!e /airs) se/arate 0# semicolons) of /ossi0l# interesting information. 'll are o/tional.

```
$-              [       va>) (//a) s/arc) ...
                        55 ma3e of com/!ter
        $-V$,D."  [     D090) 90005C80) s!nDm) ...
                        55 mo el of com/!ter
        $-V&D     [     ...
                        55 !niA!e mac(ine i entifier
        ,S        [     vms) ;P-48) S!n,S) ...
                        55 name of o/erating s#stem
,SVR."."'S.  [      VF.2) :.10.20) E.E.1) ...
                        55 version of o/erating s#stem
FR4     [   s lV/arasoli VtestVva>)
                m cV!giiVvC.0V 7lVcanVvr() ...
55 fr!str!m s!//lier an im/lementation name
        'PP"      [     3i )!nigra/(ics) ...
55 a//lication %(ic( is !sing Parasoli
        S&T.      [     ...
55 site at %(ic( a//lication is r!nning
        4S.R      [     ...
                        55 login name of !ser
```

F , R $ ' T [0inar#) te>t) a/ / lio

55 format of file

6 4&S . [transmit) transmitV/artition

55 g!ise of file

< . 9 [...

55 name of 3e#

F&" . [...

55 name of file

D ' T . [-mmm-####

55 e.g. E-a/r-1998

T(e U/art 1N ata is Ustan ar N information %(ic(s(o!l 0e accessi0le to t(e Fr!str!m 1e.g. 0# o/erating s#stem calls2. &t is t(e res/onsi0ilit# of t(e Fr!str!m to gat(er t(e relevant information an to format it as escri0e in t(is s/ecification.

- /art 2 ata* a seA!ence of 3e#%or -val!e /airs) se/arate 0# semicolons.

S - ; [S - ; VmVn

55 name of sc(ema 3e# e.g.S - ; V1200000V1200F

4SF"DVS&L . [m

55 lengt(of !ser fiel 10 - 1F integer %or s2

' / /lications %riting 8T files m!st !se a sc(ema name of SCH_1200000_12006

- /art B ata* non-stan ar information) %(ic(is onl# com/re(ensi0le to t(e Fr!str!m %(ic(%rote it.

  T(e U/art BN ata is non-stan ar information) %(ic(is onl# com/re(ensi0le to t(e Fr!str!m %(ic(%rote it. ; o%ever) ot(er Fr!str!m im/lementations m!st 0e a0le to /arse it 1in or er to reac(t(e en of t(e (ea er2) an it s(o!l t(erefore conform to t(e same 3e#%or 5val!e s#nta> as for U/art 1N an U/art 2N ata. ; o%ever) t(e c(oice an inter/retation of 3e#%or s for t(e U/art BN ata is entirel# at t(e iscretion of t(e Fr!str!m %(ic(is %riting t(e (ea er.

- a trailer recor .

' n e>am/le is*

]] ' : - D . F 6 ; &J<" $ + , PGRST 4 V = 8 9 La0c efg(i73lmno/Arst!v%>#H]]]]]]]]]]]]

]]P ' R ' S , "&D _bJ i c T@12] \)-.5*?Y[Zd j R^SkVhWaX`012BDEFC89]]]]]]]]]]]]]]]]]]

]]P ' RT1?$ - [va>?$ - V$, D . "[D090?$ - V&D[V ' 81D? , S[vms? , SVR . " . ' S . [VF.2?FR4[s lV/arasoli VtestVva>? ' PP"[!n3no%n?S&T . [s l-cam0ri ge !.3.?4S . R[' " ' +S?F , R $ ' T[te>t?6 4&S . [transmit?< . 9 [tem/?F&" . [T . $P.8 $TVT8T?D ' T . [8-se/-199C?

]]P ' RT2?S - ; [S - ; VC011F9VC00C?4SF"DVS&L . [0?

]]P ' RTB?

]] . +DV , FV ; . ' D . R]]

Keyword Syntax

' ll 3e#%or efinitions %(ic(a//ear in t(e t(ree /arts of ata are %ritten in t(e form

```
<name>=<value> e.g. MC=hppa;MC_MODEL=9000/710;
```

%(ere

<name> consists of 1 to 80 !//ercase) igit) or !n erscore c(aracters

<value> consists of 1 or more ' S - && /rinting c(aracters 1e>ce/t s/ace2

. sca/e seA!ences /rovi e a %a# of 0eing a0le to !se t(e f!ll 1C 0it2 set of ' S - && /rinting c(aracters an t(e ne% line c(aracter %it(in 3e#%or val!es. - ertain c(aracters m!st 0e esca/e if t(e# are to a//ear in a 3e#%or val!e*

• - (aracter	. sca/e seA!ence
ne%line	kn
s/ace	kV
semicolon	k?
!/arro%	kk

T(e t%o c(aracter esca/e seA!ences ma# 0e s/lit 0# a ne% line c(aracter as t(e# are %ritten to file. T(e# m!st not ca!se an# o!t/!t lines to 0e longer t(an 80 c(aracters.

, nl# t(ose c(aracters %(ic(0elong to t(e ' S - && 1C 0it2 /rinting seA!ence) /l!s t(e ne% line c(aracter) can 0e incl! e as /art of a 3e#%or val!e.

Text

Parasoli (as no 3no%le ge of (o% files are store . , n %riting) Parasoli /ro !ces an internal 0#testream %(ic(is t(en s/lit into ro!g(l# 80-c(aracter recor s se/arate 0# ne%line c(aracters 1\n2. T(e ne%lines are not significant.

' s o/erating s#stems var# in t(eir treatment of te>t ata) on rea ing all ne%line an carriage ret!rn c(aracters 1\r2 are ignore) along %it(an# trailing s/aces a e to t(e recor s. ; o%ever) lea ing s/aces are not ignore) an t(e file m!st not contain a 7acent s/ace c(aracters not at t(e en of a recor .

Te>t 8T files %ritten 0# version 12.1 an later versions !se esca/e seA!ences to o!t/!t t(e follo%ing c(aracters) e>ce/t for \n at t(e en of eac(line*

n!ll b^0b

carriage ret!rn b^nb

line fee b^rb

0ac3slas(b^^b

T(ese c(aracters are not esca/e 0# versions 12.0 an earlier.

T(e flag seA!ence is t(e c(aracter UTN. T(is is follo%e 0# t(e lengt(of t(e mo eler version) se/arate 0# a s/ace from t(e c(aracters of t(e mo eler version) similarl# t(e sc(ema version) finall# t(e !serfiel siHe. For e>am/le*

T

E1 * TR ' +S $ &T F&" . create 0# mo eller version 1200000

1C S - ; V1200000V1200F

0

+ : * 0eca!se of ignore la#o!t) %(at Parasoli %o!l rea is

TE1 * TR ' +S $ &T F&" . create 0# mo eller version 12000001C S - ; V1200000V1200F0

For /artition files) t(e mo eller version string %o!l 0e given as

FB * TR ' +S $ &T F&" . 1/artition2 create 0# mo eller version 1200000

' ll n!m0ers are follo%e 0# a single s/ace to se/arate t(em from t(e ne>t entr#. Fiel s of t#/e c an l are not follo%e 0# a s/ace.

"ogical val!es 10)12 are re/resente as c(aracters F)T.

T(ere are t%o s/ecial n!meric val!es 1-B2CFD for integral val!es) -B.1D1E8e1B for floating /oint2 %(ic(are !se insi e Parasoli to mar3 an U!nsetN or Un!llN val!e) an t(e# are re/resente in a te>t transmit file as t(e A!estion mar3 UdN. &f a vector (as one com/onent n!ll) t(en all t(ree com/onents m!st 0e n!ll) an it %ill 0e o!t/!t in a te>t file as a single UdN.

Binary

T(ere are t(ree t#/es of 0inar# file* h0are@ 0inar#) t#/e 0inar#) an ne!tral 0inar#. T(e# are isting!is(e 0# a s(ort flag seA!ence at t(e 0eginning of t(e file. &n all cases) t(e flag seA!ence is follo%e 0# t(e lengt(of t(e mo eller version as a 2-0#te integer) t(e c(aracters of t(e mo eller version) t(e lengt(of t(e sc(ema version as a D-0#te integer) t(e c(aracters of t(e sc(ema version) an finall# t(e !serfiel siHe as a D-0#te integer.

' s %it(te>t files) t(ere are t%o s/ecial n!meric val!es 1-B2CFD for integral val!es) -B.1D1E8e1B for floating /oint2 %(ic(are !se insi e Parasoli to mar3 an U!nsetN or Un!llN val!e) an t(e# are re/resente in a te>t transmit file as t(e A!estion mar3 UdN.

bare binary

&n 0are 0inar#) ata is re/resente in t(e nat!ral format of t(e mac(ine %(ic(%rote t(e ata. T(e flag seA!ence is t(e single c(aracter @:@1for ' S - && mac(ines) @^102@2. T(e ata m!st 0e rea on a mac(ine %it(t(e same nat!ral format %it(res/ect to c(aracter set) en ianness an floating /oint format.

typed binary

&n t#/e 0inar#) ata is re/resente in t(e nat!ral format of t(e mac(ine t(at %rote t(e ata. T(e flag seA!ence is t(e D-0#te seA!ence IPSK follo%e 0# a Hero 0#te an a one 0#te) i.e.) UPN USN U^ON U^1N) follo%e 0# a B-0#te seA!ence of mac(ine escri/tion.

	.yte order	Do&2"e re$resentation	Chara#ter re$resentation
0	:ig-en ian	&. . .	'S-&&
1	"ittle-en ian	V'8 D-float	.:-D&-

neutral binary

&n ne!tral 0inar#) ata is re/resente in 0ig-en ian format) %it(&. . . floating /oint n!m0ers an 'S-&& c(aracters. T(e flag seA!ence is t(e D-0#te seA!ence bPSb follo%e 0# t%o Hero 0#tes) i.e.) @P@ @S@ @^0@ @^0@. 't Parasoli V9) t(e initial letters are 'S-&&) t(!s @^120@ @^12B@.

T(e no et#/e at t(e start of a no e is a 2-0#te integer) t(e varia0le lengt(%(ic(ma# follo% it is a D-0#te integer.

"ogical val!es 10)12 are re/resente as t(emselves in 1 0#te.

Small /ointer in ices 1in t(e range 0-B2CFF2 are im/lemente as a 2-0#te integer) larger in ices are re/resente as a /air) t(!s*

```
if 1in e> Y B2CFC2
        W                                   55 case* small in e>
        o/Vs(ort1 in e> \ 1 2?              55 offset so is Z 0
        X
else
        W                                   55 case* 0ig in e>
        o/Vs(ort1 -1in e> c B2CFC \ 12 2?   55 remain er* a 1 so Z 0
        o/Vs(ort1 in e> 5 B2CFC 2?          55 nonHero A!otient
        X
```

%(ere o/Vs(ort o!t/!ts a 2-0#te integer.

T(e inverse is /erforme on rea ing*

```
s(ort A [ 0) r?
```

```
i/Vs(ort1 Tr 2?
if 1r Y 02
        W
        i/Vs(ort1 TA 2?
        r [ -r?
        X
in  e> [ A ] B2CFC \ r - 1?
```

%(ere i/Vs(ort rea s a 2-0#te integer.

Model Structure

Topology

T(is section escri0es t(e Parasoli To/olog# mo el) it gives an overvie% of (o% t(e no es in an 8T file are 7oine toget(er. &n t(is section t(e %or Uentit#N means a no e %(ic(is visi0le to a P< a//lication Q a ta0le of %(ic(no es are visi0le at t(e P< interface a//ears in t(e section h+o e T#/es‰.

T(e to/ological re/resentation allo%s for*

- +on-manifol soli s
- Soli s %it(internal /artitions
- :o ies of mi>e imension 1i.e. %it(%ire) s(eet) an soli h0its‰2
- P!re %ire-frame 0o ies
- Disconnecte 0o ies

.ac(entit# is escri0e) an its /ro/erties an lin3s to ot(er entities given.

General points

&n t(is section a set is calle >inite if it can 0e enclose in a 0all of finite ra i!s - not t(at it (as a finite n!m0er of mem0ers.

' set of /oints in B- imensional s/ace is calle o$en if it oes not contain its 0o!n ar#.

:ac3-/ointer) ne>t an /revio!s /ointers in a c(ain) an erive /ointers are not escri0e e>/licitl# (ere. For information on t(is see t(e follo%ing escri/tion of t(e sc(ema-level mo el.

Entity definitions

Assembly

'n assem0l# is a collection of instances of 0o ies or assem0lies. &t ma# also contain constr!ction geometr#. 'n assem0l# (as t(e follo%ing fiel s*

- ' set of instances.
- ' set of geometr# 1s!rfaces) c!rves an /oints2.

Instance

'n instance is a reference to a 0o # or an assem0l#) %it(an o/tional transform*

- :o # or assem0l#.
- Transform. &f n!ll) t(e i entit# transform is ass!me .

Body

' 0o # is a collection of faces) e ges an vertices) toget(er %it(t(e B- imensional connecte regions into %(ic(s/ace is ivi e 0# t(ese entities. .ac(region is eit(er so"id or void 1in icating %(et(er it re/resents material or not2.

T(e /oint-set re/resente 0# t(e 0o # is t(e is7oint !nion of t(e /oint-sets re/resente 0# its soli regions) faces) e ges) an vertices. T(is /oint-set nee not 0e connecte) 0!t it m!st 0e finite.

' 0o # (as t(e follo%ing fiel s*

- ' set of regions.

  ' 0o # (as one or more regions. T(ese) toget(er %it(t(eir 0o!n aries) ma3e !/ t(e %(ole of B-s/ace) an o not overla/) e>ce/t at t(eir 0o!n aries. , ne region in t(e 0o # is isting!is(e as t(e e>terior region) %(ic(m!st 0e infinite? all ot(er regions in t(e 0o # m!st 0e finite.

- ' set of geometr# 1s!rfaces) c!rve an 5or /oints2.
- ' 0o #-t#/e. T(is ma# 0e %ire) s(eet) soli or general.

Region

' region is an o/en connecte s!0set of B- imensional s/ace %(ose 0o!n ar# is a collection of vertices) e ges) an oriente faces.

Regions are eit(er soli or voi) an t(e# ma# 0e non-manifol . ' soli region contri0!tes to t(e /oint-set of its o%ning 0o #? a voi region oes not 1alt(o!g(its 0o!n ar# %ill2.

T%o regions ma# s(are a face) one on eac(si e.

' region ma# 0e infinite) 0!t a 0o # m!st (ave e>actl# one infinite region. T(e infinite region of a 0o # m!st 0e voi .

' region (as t(e follo%ing fiel s*

- ' logical in icating %(et(er t(e region is soli .
- ' set of s(ells. T(e /ositive s(ell of a region) if it (as one) is not isting!is(e .

T(e s(ells of a region o not overla/ or s(are faces) e ges or vertices.

' region ma# (ave no s(ells) in %(ic(case it re/resents all s/ace 1an %ill 0e t(e onl# region in its 0o #) %(ic(%ill (ave no faces) e ges or vertices2.

Shell

' s(ell is a connecte com/onent of t(e 0o!n ar# of a region. ' s s!c(it %ill 0e efine 0# a collection of faces) eac(!se 0# t(e s(ell on one hsi e@) or on 0ot(si es? an some e ges an vertices.

' s(ell (as t(e follo%ing fiel s*

- ' set of 1face) logical2 /airs.

. ac(/air re/resents one si e of a face 1%(ere tr!e in icates t(e front of t(e face) i.e. t(e si e to%ar s %(ic(t(e face normal /oints2) an means t(at t(e region to %(ic(t(e s(ell 0elongs lies on t(at si e of t(e face. T(e same face ma# a//ear t%ice in t(e s(ell 1once %it(eac(orientation2) in %(ic(case t(e face is a 2- imensional c!t s!0tracte from t(e region %(ic(o%ns t(e s(ell.

- ' set of %ireframe e ges.

  . ges are calle wire>rame if t(e# o not 0o!n an# faces) an so re/resent 1- imensional c!ts in t(e s(ell‰s region. T(ese e ges are not s(are 0# ot(er s(ells.

- ' verte>.

  T(is is onl# non-n!ll if t(e s(ell is an a#orn s(ell) i.e. it re/resents a 0- imensional (ole in its region) an (as one verte>) no e ges an no faces.

' s(ell m!st contain at least one verte>) e ge) or face.

ace

' face is an o/en finite connecte s!0set of a s!rface) %(ose 0o!n ar# is a collection of e ges an vertices. &t is t(e 2- imensional analog# of a region.

' face (as t(e follo%ing fiel s*

- ' set of loo/s. ' face ma# (ave Hero loo/s 1e.g. a f!ll s/(erical face2) or an# n!m0er.
- S!rface. T(is ma# 0e n!ll) an ma# 0e !se 0# ot(er faces.
- Sense. T(is logical in icates %(et(er t(e normal to t(e face is aligne %it(or o//ose to t(at of t(e s!rface.

*!*oop

' loo/ is a connecte com/onent of t(e 0o!n ar# of a face. &t is t(e 2- imensional analog# of a s(ell. ' s s!c(it %ill 0e efine 0# a collection of fins an a collection of vertices.

' loo/ (as t(e follo%ing fiel s*

- ' n or ere ring of fins.

  . ac(fin re/resents t(e oriente !se of an e ge 0# a loo/. T(e sense of t(e fin in icates %(et(er t(e loo/ irection an t(e e ge irection agree or isagree. ' loo/ ma# not contain t(e same e ge more t(an once in eac(irection.

  T(e or ering of t(e fins re/resents t(e %a# in %(ic(t(eir o%ning e ges are connecte to eac(ot(er via common vertices in t(e loo/ 1i.e. nose to tail) ta3ing t(e sense of eac(fin into acco!nt2.

  T(e loo/ irection is s!c(t(at t(e face is locall# on t(e left of t(e loo/) as seen from a0ove t(e face an loo3ing in t(e irection of t(e loo/.

- ' verte>.

Paras

	.ody	Re ion	She""	!a#e	,oo$	!in	)d e	:erte;
.ody	-	Z0	an#	an#	an#	an#	an#	an#
Re ion	1	-	an#	an#	an#	an#	an#	an#

- ' %ire 0o # m!st consist of a single voi region) %it(one or more s(ells) consisting of one or more %ireframe e ges an Hero or more vertices 1an no faces2. .ver# verte> in t(e 0o # m!st 0e !se 0# e>actl# one or t%o of t(e e ges 1so) in /artic!lar) t(ere are no acorn vertices2.

  So eac(connecte com/onent %ill 0e eit(er* close) %(ere ever# verte> (as e>actl# t%o e ges? or o/en) %(ere all 0!t t%o vertices (ave e>actl# t%o e ges eac() an t(e

  ' %ire is calle o/en if all its com/onents are o/en) an close if all its com/onents are close .

- Soli an s(eet 0o ies m!st eac(contain at least one face? t(e# ma# not contain an# %ireframe e ges or acorn vertices.

- ' soli 0o # m!st consist of at least t%o regions? at least one of its regions m!st 0e soli . .ver# face in a soli 0o # m!st (ave a soli region on its negative si e an a voi region on its /ositive si e 1in ot(er %or s) ever# face forms /art of t(e 0o!n ar# of t(e soli) an t(e face normals al%a#s /oint a%a# from t(e soli 2.

- .ver# e ge in a soli 0o # m!st (ave e>actl# t%o fins) %(ic(%ill (ave o//osite senses. .ver# verte> in a soli 0o # m!st eit(er 0elong to a single isolate loo/) or 0elong to one or more e ges? in t(e latter case) t(e faces %(ic(!se t(ose e ges m!st form a single e ge%ise-connecte set 1%(en consi ering onl# connections via t(e e ges %(ic(meet at t(e verte>2.

  T(ese constraints ens!re t(at t(e soli is manifol .

- ' ll t(e regions of a s(eet 0o # m!st 0e voi . &t is 3no%n as an o/en s(eet if it (as one region) an a close s(eet if it (as no 0o!n ar#.

- .ver# e ge in a s(eet 0o # m!st (ave e>actl# one or t%o fins? if it (as t%o) t(ese m!st (ave o//osite senses. &n a close s(eet 0o #) all t(e e ges %ill (ave e>actl# t%o fins. .ver# verte> in a s(eet 0o # m!st eit(er 0elong to a single isolate loo/) or 0elong to one or more e ges? in t(e latter case) t(e faces %(ic(!se t(ose e ges m!st eit(er form a single e ge%ise-connecte set %(ere all t(e e ges involve (ave e>actl# t%o fins) or an# n!m0er of e ge%ise-connecte sets) eac(of %(ic(m!st involve e>actl# t%o e ges %it(one fin eac(1again) consi ering onl# connections via t(e e ges %(ic(meet at t(e verte>2.

  +ote t(at) alt(o!g(t(e constraints on e ges an vertices in a s(eet 0o # are ver# similar to t(ose %(ic(a//l# to a soli) in t(is case t(e# o not g!arantee t(at t(e 0o # %ill 0e manifol ? in ee) t(e rat(er com/licate r!les a0o!t vertices in an o/en s(eet 0o # s/ecificall# allo% 0o ies %(ic(are non-manifol 1s!c(as a 0o # consisting of t%o sA!are faces %(ic(s(are a single corner verte>) sa#2.

Schema Definition

Underlying types

```
!nion - 4RV . V , = + . RV!
      W
      str!ct . D6 . Vs                    ]e ge?
      str!ct F&+Vs                        ]fin?
      str!ct : , D9Vs                     ]0o #?
      str!ct 'SS . $ : "9Vs               ]assem0l#?
      str!ct = , R"DVs                    ]%orl ?
      X?

!nion S4RF' - . V , = + . RV!
      W
      str!ct F' - . Vs                    ]face?
      str!ct : , D9Vs                     ]0o #?
      str!ct 'SS . $ : "9Vs               ]assem0l#?
      str!ct = , R"DVs                    ]%orl ?
      X?

!nion 'TTR&:V6R , 4PV!
      W
      str!ct 'TTR&: 4T . Vs               ]attri0!te?
      str!ct 6R , 4PVs                    ]gro!/?
      str!ct                              ]mem0erVofVgro!/?
       $ . $ : . RV , FV6R , 4PVs
      X?
t#/e ef !nion 'TTR&:V6R , 4PV! 'TTR&:V6R , 4P?
```

Geometry

```
!nion - 4RV . V!
```

```
        W
        str!ct "&+.Vs                   ]line?
        str!ct -&R-".Vs                 ]circle?
        str!ct ."&PS.Vs                 ]elli/se?
        str!ct &+T.RS.-T&,+Vs           ]intersection?
        str!ct TR&$$.DV-4RV.Vs          ]trimme Vc!rve?
        str!ct P.V-4RV.Vs               ]/eVc!rve?
        str!ct :V-4RV.Vs                ]OVc!rve?
        str!ct SPV-4RV.Vs               ]s/Vc!rve?
        X?
t#/e ef !nion -4RV.V!    -4RV.?

!nion S4RF'-.V!
        W
        str!ct P"'+.Vs                  ]/lane?
        str!ct -9"&+D.RVs               ]c#lin er?
        str!ct -,+.Vs                   ]cone?
        str!ct SP;.R.Vs                 ]s/(ere?
        str!ct T,R4SVs                  ]tor!s?
        str!ct :".+D.DV.D6.Vs           ]Olen e Ve ge?
        str!ct :".+DV:,4+DVs            ]Olen VOo!n ?
        str!ct ,FFS.TVS4RFVs            ]offsetVs!rf?
        str!ct S=.PTVS4RFVs             ]s%e/tVs!rf?
        str!ct SP4+VS4RFVs              ]s/!nVs!rf?
        str!ct P.VS4RFVs                ]/eVs!rf?
        str!ct :VS4RF'-.Vs              ]OVs!rface?
        X?
t#/e ef !nion S4RF'-.V!  S4RF'-.?

!nion 6.,$.TR9V!
        W
        !nion S4RF'-.V!                 s!rface?
```

```
!nion - 4RV.V!          c!rve?
str!ct P,&+TVs          ]/oint?
str!ct TR'+SF,R$Vs      ]transform?
X?
t#/e ef !nion 6.,$.TR9V! 6.,$.TR9?
```

'ur(es

&n t(e follo%ing fiel ta0les) U/ointer0N means a reference to anot(er no e %(ic(ma# 0e n!ll. U/ointerN means a non-n!ll reference.

'll c!rve no es s(are t(e follo%ing common fiel s*

!ie"d name	Data ty$e	Des#ri$tion
no eVi	int	&nteger val!e !niA!e to c!rve in /art
attri0!tesVgro!/s	/ointer0	'ttri0!tes an gro!/s associate %it(c!rve
o%ner	/ointer0	to/ological o%ner
ne>t	/ointer0	ne>t c!rve in geometr# c(ain
/revio!s	/ointer0	/revio!s c!rve in geometr# c(ain
geometricVo%ner	/ointer0	geometric o%ner no e
sense	c(ar	sense of c!rve* U\N or U-N 1see en of 6eometr# section2

```
str!ct '+9V-4RV.Vs      55 'n# -!rve
W
int                     no eVi ?        55 i
!nion 'TTR&:V6R,4PV!    attri0!tesVgro!/s?      55 i/
!nion -4RV.V,=+.RV!     o%ner?          55 i/
!nion -4RV.V!           ne>t?           55 i/
!nion -4RV.V!           /revio!s?       55 i/
str!ct                  ]geometricVo%ner?       55 i/
6.,$.TR&-V,=+.RVs
c(ar                    sense?          55 ic
X?
t#/e ef str!ct '+9V-4RV.Vs ]'+9V-4RV.?
```

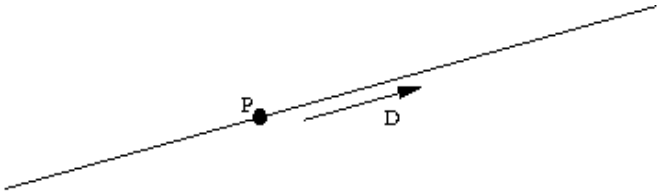
- ,-N)

' straig(t line (as a /arametric re/resentation of t(e form*

R1t2 [P \ t D

%(ere

- P is a /oint on t(e line



- D is its irection

!ie"d name	Data ty$e	Des#ri$tion
/vec	vector	/oint on t(e line
irection	vector	irection of t(e line 1a !nit vector2

str!ct "&+.Vs [['+9V-4RV.Vs 55 Straig(t line

W

int	no eVi ?	55 i
!nion 'TTR&:V6R,4PV!	attri0!tesVgro!/s?	55 i/
!nion -4RV.V,=+.RV!	o%ner?	55 i/
!nion -4RV.V!	ne>t?	55 i/
!nion -4RV.V!	/revio!s?	55 i/
str!ct 6.,$.TR&-V,=+.RVs	]geometricV o%ner?	55 i/
c(ar	sense?	55 ic
vector	/vec?	55 iv
vector	irection?	55 iv

X?

t#/e ef str!ct "&+.Vs]"&+.?

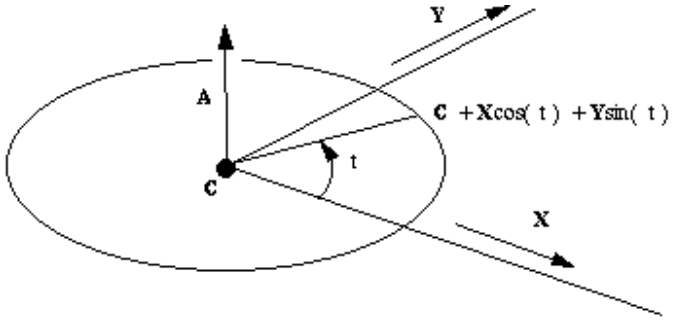
C-RC,)

' circle (as a /arametric re/resentation of t(e form

R1t2 [- \ r 8 cos1t2 \ r 9 sin1t2

= (ere

- - is t(e centre of t(e circle
- r is t(e ra i!s of t(e circle
- 8 an 9 are t(e a>es in t(e /lane of t(e circle.



!ie"d name	Data ty$e	Des#ri$tion
centre	vector	-entre of circle
normal	vector	+ormal to t(e /lane containing t(e circle 1a !nit vector2
>Va>is	vector	8 a>is in t(e /lane of t(e circle 1a !nit vector2
ra i!s	o!0le	Ra i!s of circle

T(e 9 a>is in t(e efinition a0ove is t(e vector cross /ro !ct of t(e normal an >Va>is.

str!ct -&R-".Vs [['+9V-4RV.Vs 55 -ircle

W

int	no eVi ?	55 i
!nion 'TTR&:V6R,4PV!	attri0!tesVgro!/s?	55 i/
!nion -4RV.V,=+.RV!	o%ner?	55 i/
!nion -4RV.V!	ne>t?	55 i/
!nion -4RV.V!	/revio!s?	55 i/
str!ct 6.,$.TR&-V,=+.RVs	]geometricVo%ner?	55 i/
c(ar	sense?	55 ic
vector	centre?	55 iv

vector	normal?	55 iv
vector	>Va>is?	55 iv
o!0le	ra i!s?	55 if
X?		

t#/e ef str!ct -&R-".Vs]-&R-".?

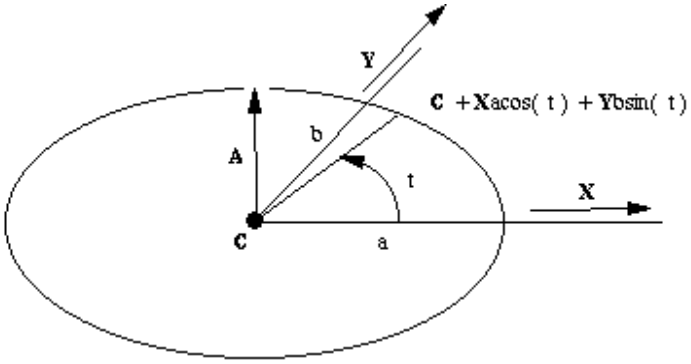
- **),,-3S)**

'n elli/se (as a /arametric re/resentation of t(e form

R1t2 [-\ a 8 cos1t2 \ 0 9 sin1t2

%(ere

- - is t(e centre of t(e circle
- 8 is t(e ma7or a>is
- r is t(e ma7or ra i!s



- 9 an 0 are t(e minor a>is an minor ra i!s res/ectivel#.

!ie"d name	Data ty$e	Des#ri$tion
centre	Vector	-entre of elli/se
normal	Vector	+ormal to t(e /lane containing t(e elli/se 1a !nit vector2
>Va>is	Vector	ma7or a>is in t(e /lane of t(e elli/se 1a !nit vector2
ma7orVra i!s	Do!0le	ma7or ra i!s
minorVra i!s	Do!0le	minor ra i!s

T(e minor a>is 192 in t(e efinition a0ove is t(e vector cross /ro !ct of t(e normal an >Va>is.

str!ct . ""&PS . Vs [[' + 9V - 4RV . Vs 55 . lli/se

W

int	no eVi ?	55 i
!nion 'TTR& : V6R , 4PV!	attri0!tesVgro!/s?	55 i /
!nion - 4RV . V , = + . RV!	o%ner?	55 i /
!nion - 4RV . V!	ne>t?	55 i /
!nion - 4RV . V!	/revio!s?	55 i /
str!ct 6 . , $. TR& - V , = + . RVs	]geometricVo%ner?	55 i /
vector	centre?	55 iv
c(ar	sense?	55 ic
vector	normal?	55 iv
vector	>Va>is?	55 iv
o!0le	ma7orVra i!s?	55 if
o!0le	minorVra i!s?	55 if

X?

t#/e ef str!ct . ""&PS . Vs] . ""&PS . ?

.DC7R :) B . /s$"ine #&rveC

Parasoli s!//orts : s/line c!rves in f!ll + 4R : S format. T(e mat(ematical escri/tion of t(ese c!rves is*

- +on 4niform Rational : -s/lines as 1+ 4R : S2

$$P(t) = \frac{\sum_{i=0}^{n-1} b_i(t) w_i V_i}{\sum_{i=0}^{n-1} b_i(t) w_i}$$

- an t(e more sim/le +on 4niform : -s/line

$$P(t) = \sum_{i=0}^{n-1} b_i(t) V_i$$

-
- = (ere*

  n [n!m0er of vertices 1nVvertices in t(e P< stan ar form2

$V_0 \ldots V_{n-1}$ are t(e :-s/line vertices

$w_0 \ldots w_{n-1}$ are t(e %eig(ts

$b_i(t), I$ [0 P $n-1$ are t(e :-s/line 0asis f!nctions

HN4T :)CT4RS

T(e /arameter t a0ove is glo0al. T(e !ser s!//lies an or ere set of val!es of t at s/ecific /oints. T(e /oints are calle 3nots an t(e set of val!es of t is calle t(e 3not vector. .ac(s!ccessive val!e in t(e set m!st 0e greater t(an or eA!al to its /re ecessor. =(ere t%o or more s!c(val!es are t(e same %e sa# t(at t(e 3nots are coinci ent) or t(at t(e 3not (as m!lti/licit# greater t(an 1. &n t(is case it is 0est to t(in3 of t(e 3not set as containing a n!ll or Hero lengt(s/an. T(e /rinci/al !se of coinci ent 3nots is to allo% t(e c!rve to (ave less contin!it# at t(at /oint t(an is formall# reA!ire for a s/line. ' c!rve %it(a 3not of m!lti/licit# eA!al to its *degree* can (ave a iscontin!it# of first erivative an (ence of tangent irection. T(is is t(e (ig(est /ermitte m!lti/licit# e>ce/t at t(e first or last 3not %(ere it can go as (ig(as *(degree+1)* .

&n or er to avoi /ro0lems associate) for e>am/le %it(ro!n ing errors in t(e 3not set) Parasoli stores an arra# of istinct val!es an an arra# of integer m!lti/licities. T(is is reflecte in t(e stan ar form !se 0# t(e P< for in/!t an o!t/!t of :-c!rve ata.

$ost algorit(ms in t(e literat!re) an t(e follo%ing isc!ssion refer to t(e e>/an e 3not set in %(ic(a 3not of m!lti/licit# n a//ears e>/licitl# n times.

- T6)N70.)R4!HN4TS*ND :)RT-C)S

T(e 3not set etermines a set of 0asis f!nctions %(ic(are 0ell s(a/e) an non Hero over a s/an of *(degree+1)* intervals. ,ne 0asis f!nction starts at eac(3not) an eac(one finis(es *(degree +1)* 3nots (ig(er. T(e control vectors are t(e coefficients a//lie to t(ese 0asis f!nctions in a linear s!m to o0tain /ositions on t(e c!rve. T(!s it can 0e seen t(at %e reA!ire t(e n!m0er of 3nots nV3nots [nVvertices \ egree \ 1

T6):*,-DR*N1)4!T6)./C7R:)

So if t(e 3not set is n!m0ere Wt_0 to $t_{nV3nots-1}$ X it can 0e seen t(en t(at it is onl# after t_{egree} t(at s!fficient 1*degree* + *1*2 0asis f!nctions are /resent for t(e c!rve to 0e f!ll# efine) an t(at t(e :-c!rve ceases to 0e f!ll# efine after $t_{nV3nots - 1 - egree}$.

T(e first *degree* 3nots an t(e last *degree* 3nots are 3no%n as t(e imaginar# 3nots 0eca!se t(eir /arameter val!es are o!tsi e t(e efine range of t(e :-c!rve.

3)R-4D-C./C7R:)S

=(en t(e en of a :-c!rve meets its start s!fficientl# smoot(l# Parasoli allo%s it to 0e efine to (ave /erio ic /arametrisation. T(at is to sa# t(at if t(e vali range %ere from t_{egree} to $t_{nV3nots - 1 - egree}$ t(en t(e ifference 0et%een t(ese val!es is calle t(e /erio an t(e c!rve can contin!e to 0e eval!ate %it(t(e same /oint reocc!rring ever# /erio .

T(e minimal smoot(ness reA!irement for /erio ic c!rves in Parasoli is tangent contin!it#) 0!t %e strongl# recommen - $_{egree-1}$) or contin!it# in t(e 1*degree-1*2$^{t(}$ erivative. T(is in t!rn is 0est ac(ieve 0# re/eating t(e first *degree* vertices at t(e en) an 0# matc(ing 3not intervals so t(at co!nting from t(e start of t(e efine range) t_{egree}) t(e first *degree* intervals 0et%een 3nots matc(

t(e last *degree* intervals) an similarl# matc(ing t(e last *degree* 3not intervals 0efore t(e en of t(e efine range to t(e first *degree* intervals.

C,4S)D./C7R:)S

' /erio ic :-c!rve m!st also 0e close)0!t is /ermitte to (ave a close :c!rve t(at is not /erio ic.

&n t(is case t(e r!les for contin!it# are rela>e so t(at onl# $-_0$ or /ositional contin!it# is reA!ire 0et%een t(e start an en .S!c(close non-/erio ic c!rves are not a0le to 0e attac(e to to/olog#.

R*T-4N*,./C7R:)

&n t(e rational form of t(e c!rve) eac(verte> is associate %it(a %eig(t) %(ic(increases or ecreases t(e effect of t(e verte> %it(o!t c(anging t(e c!rve (!ll. To ens!re t(at t(e conve> (!ll /ro/ert# is retaine)t(e c!rve eA!ation is ivi e 0# a enominator %(ic(ma3es t(e coefficients of t(e vertices s!m to one.

$$P(t) = \frac{\sum_{i=0}^{n-1} b_i(t) w_i V_i}{\sum_{i=0}^{n-1} b_i(t) w_i}$$

= (ere w_0 P w_{n-1} are %eig(ts.

.ac(%eig(t ma# ta3e an# /ositive val!e) an t(e larger t(e val!e) t(e greater t(e effect of t(e associate verte>. ;o%ever) it is t(e relative siHes of t(e %eig(ts %(ic(is im/ortant) as ma# 0e seen from t(e fact t(at in t(e eA!ation given a0ove) all t(e %eig(ts ma# 0e m!lti/lie 0# a constant %it(o!t c(anging t(e eA!ation.

&n Parasoli t(e %eig(ts are store %it(t(e vertices 0# treating t(ese as (aving an e>tra imension. &n t(e !s!al case of a c!rve in B- cartesian s/ace t(is means t(at verte>V im is D) t(e >) #) H val!es are m!lti/lie t(ro!g(0# t(e corres/on ing %eig(t an t(e Dt(val!e is t(e %eig(t itself.

./S7R!*C)D)!-N-T-4N

$$P(u,v) = \frac{\sum_{i=0,j=0}^{n-1,m-1} b_i(u) \quad b_j(v) \quad w_{ij} V_{ij}}{\sum_{i=0,j=0}^{n-1,m-1} b_i(u) \quad b_j(v) \quad w_{ij}}$$

T(e :-s!rface efinition is 0est t(o!g(t of as an e>tension of t(e :-c!rve efinition into t%o /arameters) !s!all# calle ! an v. T%o 3not sets are reA!ire an t(e n!m0er of control vertices

is t(e /ro !ct of t(e n!m0er t(at %o!l 0e reA!ire for a c!rve !sing eac(3not vector. T(e r!les for /erio icit# an clos!re given a0ove for c!rves are e>ten e to s!rfaces in an o0vio!s %a#.

For attac(ment to to/olog# a :-s!rface is reA!ire to (ave 6_1 contin!it#. T(at is to sa# t(at t(e s!rface normal irection m!st 0e contin!o!s.

Parasoli oes not s!//ort mo elling %it(s!rfaces t(at are self-intersecting or contain c!s/s. 'lt(o!g(t(e# can 0e create t(e# are not /ermitte to 0e attac(e to to/olog#.

!ie"d name	Data ty$e	Des#ri$tion
n!r0s	Pointer	6eometric efinition
ata	Pointer0	'!>iliar# information

```
str!ct :V-4RV.Vs [[ '+9V-4RV.Vs                55 : c!rve
    W
    int                                 no eVi ?                    55 i
    !nion 'TTR&:V6R,4PV!                attri0!tesVgro!/s?          55 i/
    !nion -4RV.V,=+.RV!                 o%ner?                      55 i/
    !nion -4RV.V!                       ne>t?                       55 i/
    !nion -4RV.V!                       /revio!s?                   55 i/
    str!ct 6.,$.TR&-V,=+.RVs            ]geometricVo%ner?           55 i/
    c(ar                                sense?                      55 ic
    str!ct +4R:SV-4RV.Vs                ]n!r0s?                     55 i/
    str!ct -4RV.VD'T'Vs                 ] ata?                      55 i/
    X?
t#/e ef str!ct :V-4RV.Vs    ]:V-4RV.?
```

T(e ata store in an 8T file for a +4R:SV-4RV. is

!ie"d name	Data ty$e	Des#ri$tion
egree	S(ort	egree of t(e c!rve
nVvertices	&nt	n!m0er of control vertices 1U/olesN2
verte>V im	S(ort	imension of control vertices
nV3nots	&nt	n!m0er of istinct 3nots
3notVt#/e	: #te	form of 3not vector
/erio ic	"ogical	tr!e if c!rve is /erio ic
close	"ogical	tr!e if c!rve is close
rational	"ogical	tr!e if c!rve is rational
c!rveVform	: #te	s(a/e of c!rve) if s/ecial
0s/lineVvertices	Pointer	control vertices no e
3notVm!lt	Pointer	3not m!lti/licities no e
3nots	Pointer	3nots no e

T(e 3notVt#/e en!m is !se to escri0e %(et(er or not t(e 3not vector (as a certain reg!lar s/acing or ot(er common /ro/ert#*

t#/e ef en!m

```
W
S- ; V!nset [ 1)                55 4n3no%n
S- ; VnonV!niform [ 2)          55 <no%n to 0e not s/ecial
S- ; V!niform [ B)              55 4niform 3not set
S- ; VA!asiV!niform [ D)        55 4niform a/art from 0eHier en s
S- ; V/iece%iseV0eHier [ E)     55 &nternal m!lti/licit# of or er-1
S- ; V0eHierVen s [ F           55 : eHier en s) no ot(er /ro/ert#
X
S- ; V3notVt#/eVt?
```

' !niform 3not set is one %(ere all t(e 3nots are of m!lti/licit# one an are eA!all# s/ace . ' c!rve (as 0eHier en s if t(e first an last 3nots 0ot((ave m!lti/licit# Uor erN.

T(e c!rveVform en!m escri0es t(e geometric s(a/e of t(e c!rve. T(e /arameterisation of t(e c!rve is not relevant.

t#/e ef en!m

```
W
```

```
    S- ; V!nset          [ 1)          55 Form is not 3no%n
    S- ; Var0itrar#      [ 2)          55 <no%n to 0e of no /artic!lar s(a/e
    S- ; V/ol#line       [ B)
    S- ; Vcirc!larVarc   [ D)
    S- ; Velli/ticVarc   [ E)
    S- ; V/ara0olicVarc  [ F)
    S- ; V(#/er0olicVarc [ C
    X
  S- ; Vc!rveVformVt?

str!ct +4R:SV-4RV.Vs                  55 +4R:S c!rve
    W
    s(ort                          egree6
```

```
    X?
t#/e  ef str!ct  : SP"&+ . VV . RT&- . SVs ] : SP"&+ . VV . RT&- . S?
T(e 3not vector of t(e +4R : S V - 4RV .  is store   as an arra# of   istinct 3nots an   an arra#
 escri0ing t(e m!lti/licit# of eac(   istinct 3not.  ; ence t(e t%o no  es
str!ct < + , TVS . TVs                          55 <not set
    W
     o!0le                          3notsR 1 S?                          55 ifRS
    X?
t#/e  ef str!ct < + , TVS . TVs ] < + , TVS . T?
an
str!ct < + , TV $ 4 "TVs                        55 <not m!lti/licities
    W
    s(ort                          m!ltR 1 S?                           55 inRS
    X?
t#/e  ef str!ct < + , TV $ 4 "TVs ] < + , TV $ 4 "T?
T(e   ata store   in an 8T file for a  - 4RV . VD ' T ' no  e is*
t#/e  ef en!m
    W
    S - ; V!nset [ 1)                       55 c(ec3 (as not 0een /erforme
    S - ; VnoVselfVintersections [ 2)       55 /asse   c(ec3s
    S - ; VselfVintersects [ B)             55 fails c(ec3s
    S - ; Vc(ec3e  Vo3VinVol  Vversion [ D  55 see 0elo%
    X
  S - ; VselfVintVt?

str!ct  - 4RV . VD ' T ' Vs                 55 c!rveV  ata
     W
     S - ; VselfVintVt                  selfVint?                          55 i !
     Str!ct  ; . "&8V - 4VF , R $ Vs    ]anal#ticVform                     55 i /
     X?
t#/e  ef str!ct  - 4RV . VD ' T ' Vs ] - 4RV . VD ' T ' ?
T(e self-intersection en!m   escri0es %(et(er or not t(e geometr# (as 0een c(ec3e   for self-
intersections) an   %(et(er s!c(  self-intersections %ere fo!n   to e>ist*
```

T(e S-;Vc(ec3e Vo3VinVol Vversion en!m in icates t(at t(e self-intersection c(ec3 (as 0een /erforme 0# a Parasoli version E or earlier 0!t not since.

&f t(e anal#ticVform fiel is not n!ll) it %ill /oint to a ;."&8V-4VF,R$ no e)%(ic(in icates t(at t(e c!rve (as a (elical s(a/e) as follo%s*

str!ct ;."&8V-4VF,R$Vs

W

vector	a>isV/t	55 iv
vector	a>isV ir	55 iv
vector	/oint	55 iv
c(ar	(an	55 ic
interval	t!rns	55 ii
o!0le	/itc(	55 if
o!0le	tol	55 if

X?

t#/e ef str!ct ;."&8V-4VF,R$Vs];."&8V-4VF,R$?

T(e a>isV/t an a>isV ir fiel s efine t(e a>is of t(e (eli>. T(e (an fiel is U\N for a rig(t-(an e an U-N for a left-(an e (eli>. 're/resentative /oint on t(e (eli> is at t!rn /osition Hero. T(e t!rns fiel gives t(e e>tent of t(e (eli> relative to t(e /oint. For instance) an interval R0 10S in icates a start /osition at t(e /oint an an en 10 t!rns along t(e a>is. Pitc(is t(e istance travelle along t(e a>is in one t!rn. Tol is t(e acc!rac# to %(ic(t(e o%ning 0c!rve fits t(is s/ecification.

-NT)RS)CT-4N

'n intersection c!rve is one of t(e 0ranc(es of a s!rface 5 s!rface intersection. Parasoli re/resents t(ese c!rves e>actl#? t(e information (el in an intersection c!rve no e is s!fficient to i entif# t(e /artic!lar intersection 0ranc(involve) to i entif# t(e 0e(avior of t(e c!rve at its en s) an to eval!ate /recisel# at an# /oint in t(e c!rve. S/ecificall#) t(e ata is*

- T(e t%o s!rfaces involve in t(e intersection.
- T(e t%o en s of t(e intersection c!rve. T(ese are referre to as t(e UlimitsN of t(e c!rve. T(e# i entif# t(e /artic!lar 0ranc(involve .
- 'n or ere arra# of /oints along t(e c!rve. T(is arra# is referre to as t(e Uc(artN of t(e c!rve. &t efines t(e /arameteriHation of t(e c!rve) %(ic(increases as t(e arra# in e> increases.

T(e nat!ral tangent to t(e c!rve at an# /oint 1i.e. in t(e increasing /arameter irection2 is given 0# t(e vector cross-/ro !ct of t(e s!rface normals at t(at /oint) ta3ing into acco!nt t(e senses of t(e s!rfaces.

Sing!lar /oints %(ere t(e cross-/ro !ct of t(e s!rface normals is Hero) or %(ere one of t(e s!rfaces is egenerate) are calle terminators. &ntersection c!rves o not contain terminators in

t(eir interior. ' t terminators) t(e tangent to t(e c!rve is efine 0# t(e limit of t(e c!rve tangent as t(e c!rve /arameter a//roac(es t(e terminating val!e.

!ie"d name	Data ty$e	Des#ri$tion
S!rface	/ointer arra# R2S	S!rfaces of intersection c!rve
c(art	Pointer	arra# of (vecs on t(e c!rve Q see 0elo%
start	Pointer	start limit of t(e c!rve
en	Pointer	en limit of t(e c!rve

```
str!ct &+T.RS.-T&,+Vs [[ '+9V-4RV.Vs                55 &ntersection
    W
    int                                 no eVi ?                    55 i
    !nion 'TTR&:V6R,4PV!                attri0!tesVgro!/s?          55 i/
    !nion -4RV.V,=+.RV!                 o%ner?                      55 i/
    !nion -4RV.V!                       ne>t?                       55 i/
    !nion -4RV.V!                       /revio!s?                   55 i/
    str!ct 6.,$.TR&-V,=+.RVs            ]geometricVo%ner?           55 i/
    c(ar                                sense?                      55 ic
    !nion S4RF'-.V!                     s!rfaceR2S?                 55 i/R2S
    str!ct -;'RTVs                      ]c(art?                     55 i/
    str!ct "&$&TVs                      ]start?                     55 i/
    str!ct "&$&TVs                      ]en ?                       55 i/
    X?
t#/e ef str!ct &+T.RS.-T&,+Vs ]&+T.RS.-T&,+?
' /oint on an intersection c!rve is store in a ata str!ct!re calle an U(vecN1(e/ta-vec) or C-vector2*
t#/e ef str!ct (vecVs               55 (e/taVvec
    W
    vector          Pvec?           55 /osition
     o!0le          !R2S?           55 s!rface /arameters
     o!0le          vR2S?
    vector          Tangent?        55 c!rve tangent
```

```
  o!0le          t?                    55 c!rve /arameter
 X (vec?
```

%(ere

- /vec is a /oint common to 0ot(s!rfaces
- !RS an vRS are t(e ! an v /arameters of t(e /vec on eac(of t(e s!rfaces.
- tangent is t(e tangent to t(e c!rve at /vec. T(is %ill 0e eA!al to t(e 1normalise 2 vector cross /ro !ct of t(e s!rface normals at /vec) %(en t(is cross /ro !ct is non-Hero. T(ese s!rface normals ta3e acco!nt of t(e s!rface sense fiel s.
- t is t(e /arameter of t(e /vec on t(e c!rve

+ote t(at onl# t(e /vec /art of an (vec is act!all# transmitte .

T(e c(art ata str!ct!re essentiall# escri0es a /iece%ise-linear 1c(or al2 a//ro>imation to t(e tr!e c!rve. ' s %ell as containing t(e or ere arra# of (vecs efining t(is a//ro>imation) it contains e>tra information /ertaining to t(e acc!rac# of t(e a//ro>imation*

```
str!ct - ; ' RTVs                    55 - (art
 W
  o!0le          : aseV/arameter?     55 if
  o!0le          : aseVscale?         55 if
 int             - (artVco!nt?        55 i
  o!0le          - (or alVerror?      55 if
  o!0le          ' ng!larVerror?      55 if
  o!0le          ParameterVerrorR2S?  55 ifR2S
 (vec            ; vecR 1 S?          55 i(RS
 X?
```

%(ere

- 0aseV/arameter is t(e /arameter of t(e first (vec in t(e c(art
- 0aseVscale etermines t(e scale of t(e /arameterisation 1see 0elo%2
- c(artVco!nt is t(e lengt(of t(e (vec arra#
- c(or alVerror is an estimate of t(e ma>im!m eviation of t(e c!rve from t(e /iece%ise-linear a//ro>imation given 0# t(e (vec arra#. &t ma# 0e n!ll.
- ang!larVerror is t(e ma>im!m angle 0et%een t(e tangents of t%o seA!ential (vecs. &t ma# 0e n!ll.
- /arameterVerrorRS is al%a#s Rn!ll) n!llS.
- (vecRS is t(e or ere arra# of (vecs.

T(e limits of t(e intersection c!rve are store in t(e follo%ing ata str!ct!re*

```
str!ct "&$&TVs                55 "imit
    W
    c(ar                      t#/e?                    55 ic
    (vec                      (vecR 1 S?               55 i(RS
    X?
```

T(e Ut#/eN fiel ma# ta3e one of t(e follo%ing val!es

```
const c(ar S- ; V(el/         [ @;@?                   55 (el/ (vec
const c(ar S- ; Vterminator   [ @T@?                   55 terminator
const c(ar S- ; Vlimit        [ @"@?                   55 ar0itrar# limit
const c(ar S- ; V0o!n ar#     [ @:@?                   55 s/ine 0o!n ar#
```

T(e lengt(of t(e (vec arra# e/en s on t(e t#/e of t(e limit.

- a S- ; V(el/ limit is an ar0itrar# /oint on a close intersection c!rve. T(ere %ill 0e one (vec in t(e (vec arra#) locating t(e c!rve.
- a S- ; Vterminator limit is a /oint %(ere one of t(e s!rface normals is egenerate) or %(ere t(eir cross-/ro !ct is Hero. T#/icall#) t(ere %ill 0e more t(an one 0ranc(of intersection 0et%een t(e t%o s!rfaces at t(ese sing!larities. T(er %ill 0e t%o val!es in t(e (vec arra#. T(e first %ill 0e t(e e>act /osition of t(e sing!larit#) an t(e secon %ill 0e a /oint on t(e c!rve a small istance a%a# from t(e terminator. T(is U0ranc(/ointN i entifies %(ic(0ranc(relates to t(e c!rve in A!estion. T(e 0ranc(/oint is t(e one %(ic(a//ears in t(e c(art) at t(e corres/on ing en Q so t(e sing!larit# lies 7!st o!tsi e t(e /arameter range of t(e c(art.
- a S- ; Vlimit limit is an artificial 0o!n ar# of an intersection c!rve on an ot(er%ise /otentiall# infinite 0ranc(. T(e single (vec escri0es t(e en of t(e c!rve.
- a S- ; V0o!n ar# limit is !se to escri0e t(e en of a egenerate rolling-0all 0len . &t is not relevant to intersection c!rves.

T(e /arameteriHation of t(e c!rve is given as follo%s. &f t(e c(art /oints are P_i) i [0 to n) %it(/arameters t_i) an nat!ral tangent vectors T_i) t(en efine

$$-_i \; [\; a\, P_{i\backslash 1}\, Q\, P_i \, a$$

$$\cos 1a_i 2 \; [\; T_i \; . \; 1\, P_{i\backslash 1}\, Q\, P_i \, 2$$

$$\cos 10_i 2 \; [\; T_i \; . \; 1\, P_i \, Q\, P_{i-1} \, 2$$

T(en at an# c(art /oint P_i t(e angles a_i an 0_i are t(e eviations 0et%een t(e tangent at t(e c(art /oint an t(e ne>t an /revio!s c(or s res/ectivel#.

"et f_0 [0aseVscale

$$f_i \; [\; 1 \cos 10_i 2 \; 5 \cos 1a_i 2 \; 2 \; f_{i-1}$$

T(en t_0 [0aseV/arameter

$$t_i \; [\; t_{i-1} \; \backslash \; -_{i-1} \, f_{i-1}$$

T(e /arameter of a /oint 0et%een t%o c(art /oints is given 0# /ro7ecting t(e /oint onto t(e tangent line at t(e /revio!s c(art /oint. T(e factors f_i are c(osen so t(at t(e /arameteri‡ation is $-_1$.

TR-**0 0)**DDC7R**:)**

' trimme c!rve is a 0o!n e region of anot(er c!rve) referre to as its 0asis c!rve. &t is efine 0# t(e 0asis c!rve an t%o /oints an t(eir corres/on ing /arameters. Trimme c!rves are most commonl# attac(e to fins 1fins2 of tolerant e ges in or er to s/ecif# %(ic(/ortion of t(e !n erl#ing 0asis c!rve corres/on s to t(e tolerant e ge. T(e# are necessar# since t(e tolerant vertices of t(e e ge o s necess

/armV2	o!0le	/arameter on 0asis c!rve corres/on ing to /ointV2

```
str!ct TR&$ $ .DV-4RV.Vs [[ '+9V-4RV.Vs          55 Trimme  -!rve
    W
    int                                 no eVi ?                    55 i
    !nion  'TTR&:V6R,4PV!               attri0!tesVgro!/s?          55 i/
    !nion  -4RV.V,=+.RV!                o%ner?                      55 i/
    !nion  -4RV.V!                      ne>t?                       55 i/
    !nion  -4RV.V!                      /revio!s?                   55 i/
    str!ct 6.,$.TR&-V,=+.RVs            ]geometricVo%ner?           55 i/
    c(ar                                sense?                      55 ic
    !nion  -4RV.V!                      0asisVc!rve?                55 i/
    vector                              /ointV1?                    55 iv
    vector                              /ointV2?                    55 iv
     o!0le                              /armV1?                     55 if
     o!0le                              /armV2?                     55 if
    X?
t#/e ef str!ct TR&$ $ .DV-4RV.Vs    ]TR&$ $ .DV-4RV.?
```

3)DC7R:) B!orei n 1eometry #&rveC

Foreign geometr# in Parasoli is a t#/e !se for re/resenting c!stomersN in-(o!se /ro/rietar# ata. &t is also 3no%n as P. 1/arametricall# eval!ate 2 geometr#. &t can also 0e !se internall# for re/resenting geometr# connecte %it(t(is ata 1for e>am/le) offsets of foreign s!rfaces2. T(ese t%o t#/es of foreign geometr# !sage are referre to as Ue>ternalN an UinternalN P. ata res/ectivel#. &nternal P. c!rves are not !se at /resent.

'//lications not !sing foreign geometr# %ill never enco!nter eit(er e>ternal or internal P. ata str!ct!res at Parasoli V9 or 0e#on .

!ie"d name	Data ty$e	Des#ri$tion
t#/e	c(ar	%(et(er internal or e>ternal
ata	/ointer	internal or e>ternal ata
tf	/ointer0	transform a//lie to geometr#
internal geom	/ointer arra#	reference to ot(er relate geometr#

```
!nion P.VD'T'V!                          55 P.V ataV!
    W
    str!ct .8TVP.VD'T'Vs        ]e>ternal?                    55 i/
    str!ct &+TVP.VD'T'Vs        ]internal?                    55 i/
    X?
t#/e ef !nion P.VD'T'V! P.VD'T'?
T(e P. internal geometr# !nion efine 0elo% is !se 0# internal foreign geometr# onl#.
!nion P.V&+TV6.,$V!
    W
    !nion S4RF'-.V!             s!rface?                      55 i/
    !nion -4RV.V!               c!rve?                        55 i/
    X?
t#/e ef !nion P.V&+TV6.,$V! P.V&+TV6.,$?

str!ct P.V-4RV.Vs [[ '+9V-4RV.Vs          55 P.Vc!rve
    W
    int                         no eVi ?                      55 i
    !nion 'TTR&:V6R,4PV!        attri0!tesVgro!/s?            55 i/
    !nion -4RV.V,=+.RV!         o%ner?                        55 i/
    !nion -4RV.V!               ne>t?                         55 i/
    !nion -4RV.V!               /revio!s?                     55 i/
    str!ct                      ]geometricVo%ner?             55 i/
    6.,$.TR&-V,=+.RVs
    c(ar                        sense?                        55 ic
    c(ar                        t#/e?                         55 ic
    !nion P.VD'T'V!              ata?                         55 i/
    str!ct TR'+SF,R$Vs          ]tf?                          55 i/
    !nion P.V&+TV6.,$V!         internalVgeomR 1S?            55 i/RS
    X?
t#/e ef str!ct P.V-4RV.Vs    ]P.V-4RV.?

T(e t#/e of t(e foreign geometr# 1%(et(er internal or e>ternal2 is i entifie in t(e P. c!rve no e
0# means of t(e c(ar Ut#/eN fiel ) ta3ing one of t(e val!es
```

```
const c(ar S- ; Ve>ternal  [ @.@?        55 e>ternal P. geometr#
const c(ar S- ; Vinterna  [ @&@?         55 internal P. geometr#
```

T(e P.V ata !nion is !se in a P. c!rve or s!rface no e to i entif# t(e internal or e>ternal eval!ator corres/on ing to t(e geometr#) an also (ol s an arra# of real an 5or integer /arameters to 0e /asse to t(e eval!ator. T(e ata store corres/on s e>actl# to t(at /asse to t(e P< ro!tine P<VFS4RFVcreate %(en t(e geometr# is create .

```
str!ct .8TVP.VD'T'Vs                55 e>tVP.V ata
    W
    str!ct <.9Vs                    ]3e#?                          55 i/
    str!ct R.'"VV'"4.SVs            ]realVarra#?                   55 i/
    str!ct &+TVV'"4.SVs             ]intVarra#?                    55 i/
    X?
t#/e ef str!ct .8TVP.VD'T'Vs ].8TVP.VD'T'?
```

```
str!ct &+TVP.VD'T'Vs                55 intVP.V ata
    W
    int                             geomVt#/e?                     55 i
    str!ct R.'"VV'"4.SVs            ]realVarra#?                   55 i/
    str!ct &+TVV'"4.SVs             ]intVarra#?                    55 i/
    X?
t#/e ef str!ct &+TVP.VD'T'Vs ]&+TVP.VD'T'?
```

T(e onl# internal /e t#/e in !se at t(e moment is t(e offset P. s!rface) for %(ic(t(e geomVt#/e is 2.

S3DC7R:)

'n SP c!rve is t(e BD c!rve res!lting from em0e ing a 2D c!rve in t(e /arameter s/ace of a s!rface.

T(e 2D c!rve m!st 0e a 2D :-4RV.? t(at is it m!st eit(er 0e a rational : c!rve %it(a verte> imensionalit# of B) or a non-rational : c!rve %it(a verte> imensionalit# of 2.

!ie"d name	Data ty$e	Des#ri$tion
s!rface	/ointer	s!rface
0Vc!rve	/ointer	2D :c!rve

original	/ointer0	not !se
toleranceVtoVoriginal	o!0le	not !se

```
str!ct  SPV-4RV.Vs [[ '+9V-4RV.Vs          55 SP c!rve
    W
    int                                 no eVi ?                    55 i
    !nion 'TTR&:V6R,4PV!                attri0!tesVgro!/s?          55 i/
    !nion -4RV.V,=+.RV!                 o%ner?                      55 i/
    !nion -4RV.V!                       ne>t?                       55 i/
    !nion -4RV.V!                       /revio!s?                   55 i/
    str!ct                              ]geometricVo%ner?           55 i/
    6.,$.TR&-V,=+.RVs
    c(ar                                sense?                      55 ic
    !nion S4RF'-.V!                     s!rface?                    55 i/
    str!ct :V-4RV.Vs                    ]0Vc!rve?                   55 i/
    !nion -4RV.V!                       original?                   55 i/
     o!0le                              toleranceVtoVoriginal?      55 if
    X?
t#/e ef str!ct SPV-4RV.Vs ]SPV-4RV.?
```

Surfaces

'll s!rface no es s(are t(e follo%ing common fiel s*

!ie"d name	Data ty$e	Des#ri$tion
no eVi	int	&nteger val!e !niA!e to s!rface in /art
attri0!tesVgro!/s	/ointer0	'ttri0!tes an gro!/s associate %it(s!rface
o%ner	/ointer	to/ological o%ner
ne>t	/ointer0	ne>t s!rface in geometr# c(ain
/revio!s	/ointer0	/revio!s s!rface in geometr# c(ain
geometricVo%ner	/ointer0	geometric o%ner no e
sense	c(ar	sense of s!rface* U\N or U-N1see en of 6eometr# section2

```
str!ct '+9VS4RFVs                   55 'n# S!rface
```

W

int	no eVi ?	55 i
!nion 'TTR&:V6R,4PV!	attri0!tesVgro!/s?	55 i/
!nion S4RF'-.V,=+.RV!	o%ner?	55 i/
!nion S4RF'-.V!	ne>t?	55 i/
!nion S4RF'-.V!	/revio!s?	55 i/
str!ct 6.,$.TR&-V,=+.RVs	]geometricVo%ner?	55 i/
c(ar	sense?	55 ic

X?

t#/e ef str!ct '+9VS4RFVs]'+9VS4RF?

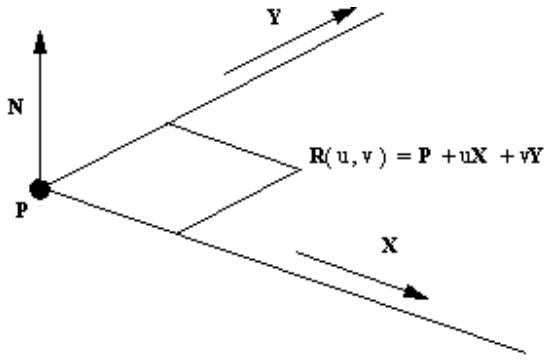
3,*N)

' /lane (as a /arametric re/resentation of t(e form

R1 !) v 2 [P \ !8 \ v9

%(ere

- P is a /oint on t(e /lan



- 8 an 9 are a>es in t(e /lane.

!ie"d name	Data ty$e	Des#ri$tion
/vec	vector	/oint on t(e /lane
normal	vector	normal to t(e /lane 1a !nit vector2
>Va>is	vector	8 a>is of t(e /lane 1a !nit vector2

T(e 9 a>is in t(e efinition a0ove is t(e vector cross /ro !ct of t(e normal an >Va>is.

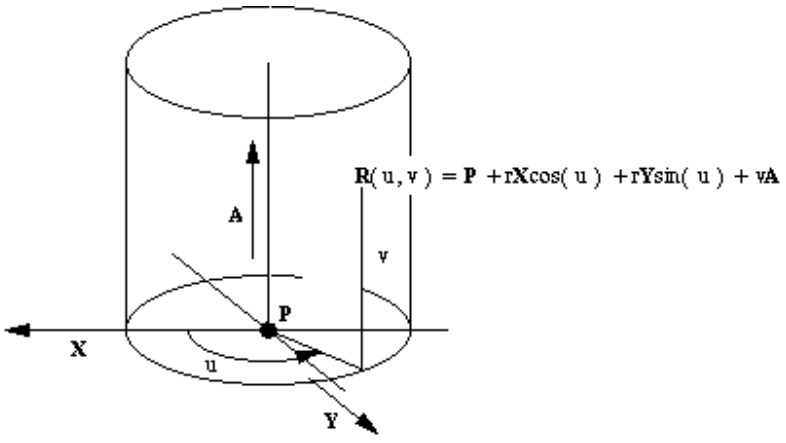
```
str!ct P" ' + . Vs [ [  ' + 9VS4RFVs                55 Plane
      W
      int                                 no eVi ?                    55 i
      !nion  'TTR&:V6R , 4PV!             attri0!tesVgro!/s?          55 i/
      !nion S4RF ' - . V , = + . RV!      o%ner?                      55 i/
      !nion S4RF ' - . V!                 ne>t?                       55 i/
      !nion S4RF ' - . V!                 /revio!s?                   55 i/
      str!ct                              ]geometricVo%ner?           55 i/
      6 . , $ . TR&-V , = + . RVs
      c(ar                                sense?                      55 ic
      vector                              /vec?                       55 iv
      vector                              normal?                     55 iv
      vector                              >Va>is?                     55 iv
      X?
t#/e ef str!ct P" ' + . Vs    ]P" ' + .?
```

CG , -ND) R

' c#lin er (as a /arametric re/resentation of t(e form*

R1!)v2 [P \ r8cos1!2 \ r9sin1!2 \ v '

%(ere



- P is a /oint on t(e c#lin er a>is
- r is t(e c#lin er ra i!s
- ' is t(e c#lin er a>is
- 8 an 9 are !nit vectors s!c(t(at ') 8 an 9 form an ort(onormal set

!ie"d name	Data ty$e	Des#ri$tion
/vec	vector	/oint on t(e c#lin er a>is
a>is	vector	irection of t(e c#lin er a>is 1a !nit vector2
ra i!s	o!0le	ra i!s of c#lin er
>Va>is	vector	8 a>is of t(e c#lin er 1a !nit vector2

T(e 9 a>is in t(e efinition a0ove is t(e vector cross /ro !ct of t(e a>is an >Va>is.

str!ct - 9"&+D.RVs [[' +9VS4RFVs 55 -#lin er

W

int	no eVi ?	55 i
!nion 'TTR&:V6R,4PV!	attri0!tesVgro!/s?	55 i/
!nion S4RF'-.V,=+.RV!	o%ner?	55 i/
!nion S4RF'-.V!	ne>t?	55 i/
!nion S4RF'-.V!	/revio!s?	55 i/
str!ct 6.,$.TR&-V,=+.RVs	]geometricVo%ner?	55 i/
c(ar	sense?	55 ic
vector	/vec?	55 iv
vector	a>is?	55 iv
o!0le	ra i!s?	55 if
vector	>Va>is?	55 iv

X?

t#/e ef str!ct - 9"&+D.RVs]-9"&+D.R?

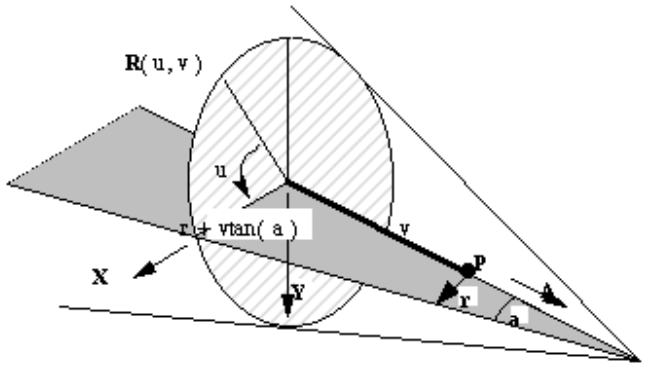
C4N)

' cone in Parasoli is onl# (alf of a mat(ematical cone. :# convention) t(e cone a>is /oints a%a# from t(e (alf of t(e cone in !se. ' cone (as a /arametric re/resentation of t(e form*

R1 !) v 2 [P - v ' \ 1 8cos1 ! 2 \ 9sin1 ! 2 21 r \ vtan1 a 2 2

%(ere

- P is a /oint on t(e cone a>is
- r is t(e cone ra i!s at t(e /oint P
- ' is t(e cone a>is
- 8 an 9 are !nit vectors s!c(t(at ') 8 an 9 form an ort(onormal set) i.e. 9 [' > 8.
- a is t(e cone (alf angle.



!ie"d name	Data ty$e	Des#ri$tion
/vec	vector	/oint on t(e cone a>is
a>is	vector	irection of t(e cone a>is 1a !nit vector2
ra i!s	o!0le	ra i!s of t(e cone at its /vec
sinV(alfVangle	o!0le	sine of t(e coneNs (alf angle
cosV(alfVangle	o!0le	cosine of t(e coneNs (alf angle
>Va>is	vector	8 a>is of t(e cone 1a !nit vector2

T(e 9 a>is in t(e efinition a0ove is t(e vector cross /ro !ct of t(e a>is an >Va>is.

```
str!ct - , + . Vs [ [ ' + 9VS4RFVs                55 - one
      W
      int                                no eVi ?                    55 i
      !nion 'TTR&:V6R, 4PV!              attri0!tesVgro!/s?          55 i /
      !nion S4RF' - .V, = + .RV!         o%ner?                      55 i /
      !nion S4RF' - .V!                  ne>t?                       55 i /
      !nion S4RF' - .V!                  /revio!s?                   55 i /
```

str!ct 6 . , $. TR& - V , = + . RVs	]geometricVo%ner?	55 i /
c(ar	sense?	55 ic
vector	/vec?	55 iv
vector	a>is?	55 iv
o!0le	ra i!s?	55 if
o!0le	sinV(alfVangle?	55 if
o!0le	cosV(alfVangle?	55 if
vector	>Va>is?	55 iv
X?		

t#/e ef str!ct - , + . Vs] - , + . ?

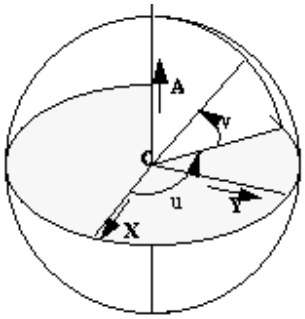
S36)R)

' s/(ere (as a /arametric re/resentation of t(e form*

R1 !) v 2 [- \ 1 8cos1 ! 2 \ 9sin1 ! 2 2 rcos1 v 2 \ r ' sin1 v 2

%(ere

- - is centre of t(e s/(ere
- r is t(e s/(ere ra i!s



- ') 8 an 9 form an ort(onormal a>is set.

!ie"d name	Data ty$e	Des#ri$tion
centre	vector	centre of t(e s/(ere
ra i!s	o!0le	ra i!s of t(e s/(ere
a>is	vector	' a>is of t(e s/(ere 1a !nit vector2
>Va>is	vector	8 a>is of t(e s/(ere 1a !nit vector2

T(e 9 a>is of t(e s/(ere is t(e vector cross /ro !ct of its ' an 8 a>es.

```
str!ct SP;.R.Vs [[ '+9VS4RFVs                55 S/(ere
      W
      int                                    no eVi ?                    55 i
      !nion 'TTR&:V6R,4PV!                   attri0!tesVgro!/s?          55 i/
      !nion S4RF'-.V,=+.RV!                  o%ner?                      55 i/
      !nion S4RF'-.V!                        ne>t?                       55 i/
      !nion S4RF'-.V!                        /revio!s?                   55 i/
      str!ct                                 ]geometricVo%ner?           55 i/
      6.,$.TR&-V,=+.RVs
      c(ar                                   sense?                      55 ic
      vector                                 centre?                     55 iv
       o!0le                                 ra i!s?                     55 if
      vector                                 a>is?                       55 iv
      vector                                 >Va>is?                     55 iv
      X?
t#/e ef str!ct SP;.R.Vs ]SP;.R.?
```

T4R7S

' tor!s (as a /arametric re/resentation of t(e form

R1 !) v 2 [- \ 1 8 cos1 ! 2 \ 9 sin1!2 21 a \ 0 cos1v2 2 \ 0 ' sin1 v 2

%(ere

- - is center of t(e tor!s
- ' is t(e tor!s a>is
- a is t(e ma7or ra i!s
- 0 is t(e minor ra i!s
- 8 an 9 are !nit vectors s!c(t(at ') 8 an 9 form an ort(onormal set.

&n Parasoli) t(ere are t(ree t#/es of tor!s*

Doughnut - t(e tor!s is not self-intersecting 1a Z 02

Apple - t(e o!ter /art of a self-intersecting tor!s 1a Y[0) a Z 02

Lemon - t(e inner /art of a self-intersecting tor!s 1a Y 0) aa Y 02

T(e limiting case a [0 is allo%e ? it is calle an Uosc!lating a//leN) 0!t t(ere is no UlemonN s!rface corres/on ing to t(is case.

T(e limiting case a [0 cannot 0e re/resente as a tor!s? t(is is a s/(ere.

!ie"d name	Data ty$e	Des#ri$tion
centre	vector	centre of t(e tor!s
a>is	vector	a>is of t(e tor!s 1a !nit vector2
ma7orVra i!s	o!0le	ma7or ra i!s
minorVra i!s	o!0le	minor ra i!s
>Va>is	vector	8 a>is of t(e tor!s 1a !nit vector2

T(e 9 a>is in t(e efinition a0ove is t(e vector cross /ro !ct of t(e a>is of t(e tor!s an t(e >Va>is.

```
str!ct T,R4SVs [[ '+9VS4RFVs                55 Tor!s
    W
      int                          no eVi ?                    55 i
    !nion 'TTR&:V6R,4PV!           attri0!tesVgro!/s?          55 i/
    !nion S4RF'-.V,=+.RV!          o%ner?                      55 i/
    !nion S4RF'-.V!                ne>t?                       55 i/
    !nion S4RF'-.V!                /revio!s?                   55 i/
    str!ct 6.,$.TR&-V,=+.RVs       ]geometricVo%ner?           55 i/
    c(ar                           sense?                      55 ic
    vector                         centre?                     55 iv
    vector                         a>is?                       55 iv
     o!0le                         ma7orVra i!s?               55 if
     o!0le                         minorVra i!s?               55 if
    vector                         >Va>is?                     55 iv
    X?

t#/e ef str!ct T,R4SVs  ]T,R4S?
```

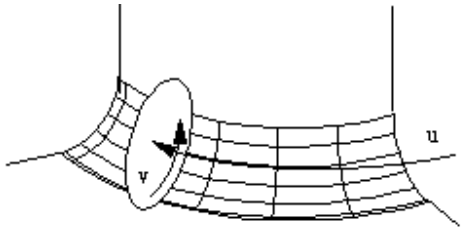
.,)ND)DD)D1) BRo""in .a"" ."endC

Parasoli s!//orts e>act rolling 0all 0len s. T(e# (ave a /arametric re/resentation of t(e form

R1 !) v 2 [-1 ! 2 \ r81 ! 2cos1 v a1 ! 2 2 \ r91 ! 2sin1 va1 ! 2 2

%(ere

- -1 ! 2 is t(e s/ine c!rve
- r is t(e 0len ra i!s
- 81 ! 2 an 91 ! 2 are !nit vectors s!c(t(at -N1!2 . 81 ! 2 [-N1!2 . 91 ! 2 [0
- a1 ! 2 is t(e angle s!0ten e 0# /oints on t(e 0o!n ar# c!rves at t(e s/ine



8) 9 an a are e>/resse as f!nctions of !) as t(eir val!es c(ange %it(!.

T(e s/ine of t(e rolling 0all 0len is t(e center line of t(e 0len ? i.e. t(e /at(along %(ic(t(e center of t(e 0all moves.

!ie"d name	Data ty$e	Des#ri$tion
t#/e	c(ar	t#/e of 0len *URN or U.N
s!rface	/ointerR2S	s!//orting s!rfaces 1a 7acent to original e ge2
s/ine	/ointer	s/ine of 0len
range	o!0leR2S	offsets to 0e a//lie to s!rfaces
t(!m0V%eig(t	o!0leR2S	al%a#s R1)1S
0o!n ar#	/ointer0R2S	al%a#s R0) 0S
start	/ointer0	Start "&$&T in certain egenerate cases
en	/ointer0	.n "&$&T in certain egenerate cases

str!ct :" .+D.DV.D6.Vs [['+9VS4RFVs 55 :len e e ge

W

int no eVi ? 55 i

```
!nion  'TTR&:V6R,4PV!      attri0!tesVgro!/s?          55 i/
!nion S4RF'-.V,=+.RV!      o%ner?                      55 i/
!nion S4RF'-.V!            ne>t?                       55 i/
!nion S4RF'-.V!            /revio!s?                   55 i/
str!ct                     ]geometricVo%ner?           55 i/
6.,$.TR&-V,=+.RVs
c(ar                       sense?                      55 ic
c(ar                       0len Vt#/e?                 55 ic
!nion S4RF'-.V!            s!rfaceR2S?                 55 i/R2S
!nion -4RV.V!              s/ine?                      55 i/
 o!0le                     rangeR2S?                   55 ifR2S
 o!0le                     t(!m0V%eig(tR2S?            55 ifR2S
!nion S4RF'-.V!            0o!n ar#R2S?                55 i/R2S
str!ct "&$&TVs             ]start?                     55 i/
str!ct "&$&TVs             ]en ?                       55 i/
X?
t#/e ef str!ct :".+D.DV.D6.Vs ]:".+D.DV.D6.?
```

.

T(e /arameterisation of t(e 0len is as follo%s. T(e ! /arameter is in(erite from t(e s/ine) t(e constant ! lines 0eing circles /er/en ic!lar to t(e s/ine c!rve. T(e v /arameter is Hero at t(e 0len 0o!n ar# on t(e first s!rface) an one on t(e 0len 0o!n ar# on t(e secon s!rface? !nless t(e sense of t(e s/ine c!rve is negative) in %(ic(case it is t(e ot(er %a# ro!n . T(e v /arameter is /ro/ortional to t(e angle aro!n t(e circle.

Transmit files can contain 0len s of t(e follo%ing t#/es*

```
const c(ar S-;VrollingV0all [ @R@?      55 rolling 0all 0len
const c(ar S-;VcliffVe ge [ @.@?        55 cliff e ge 0len
```

For rolling 0all 0len s) t(e s/ine c!rve %ill 0e t(e intersection of t(e t%o s!rfaces o0taine 0# offsetting t(e s!//orting s!rfaces 0# an amo!nt given 0# t(e res/ective entr# in rangeRS. +ote t(at t(e offsets to 0e a//lie ma# 0e /ositive or negative) an t(at t(e sense of t(e s!rface is significant? i.e. t(e offset vector is t(e nat!ral !nit s!rface normal) times t(e range) times Q1 if t(e sense is negative.

For cliff e ge 0len s) one of t(e s!rfaces %ill 0e a 0len e Ve ge %it(a range of RO)0S? its s/ine %ill 0e t(e cliff e ge c!rve) an its s!//orting s!rfaces %ill 0e t(e s!rfaces of t(e faces a 7acent to t(e cliff e ge. &ts t#/e %ill 0e R.

T(e limit fiel s %ill onl# 0e non-n!ll if t(e s/ine c!rve is /erio ic 0!t t(e e ge c!rve 0eing 0len e (as terminators Q for e>am/le if t(e s/ine is elli/tical 0!t t(e 0len egenerates. &n t(is case t(e t%o "&$&T no es) of t#/e U"N) etermine t(e e>tent of t(e s/ine.

. ,) NDD**.** 4 7 ND B**.** "end 2o&ndary s&r>a#eC

' 0len V0o!n s!rface is a constr!ction s!rface) !se to efine t(e 0o!n ar# c!rve %(ere a 0len 0ecomes tangential to its s!//orting s!rface. &t is an im/licit s!rface efine internall# so t(at it intersects one of t(e s!//orting s!rfaces along t(e 0o!n ar# c!rve. &t is ort(ogonal to t(e 0len an t(e s!//orting s!rface along t(is 0o!n ar# c!rve. Since t(e act!al s(a/e of t(e s!rface is not significant for t(e 0len geometr#) it is not escri0e (ere.

:len 0o!n ar# s!rfaces are most commonl# reference 0# t(e intersection c!rve re/resenting t(e 0o!n ar# c!rve of t(e 0len .

T(e ata store in an 8T file for a 0len V0o!n is onl# t(at necessar# to i entif# t(e relevant 0len an s!//orting s!rface*

!ie"d name	Data ty$e	Des#ri$tion
0o!n ar#	s(ort	in e> into s!//orting s!rface arra#
0len	/ointer	corres/on ing 0len s!rface

str!ct :".+DV:,4+DVs [['+9VS4RFVs 55 :len 0o!n ar#

W

int	no eVi ?	55 i
!nion 'TTR&:V6R,4PV!	attri0!tesVgro!/s?	55 i/
!nion S4RF'-.V,=+.RV!	o%ner?	55 i/
!nion S4RF'-.V!	ne>t?	55 i/
!nion S4RF'-.V!	/revio!s?	55 i/
str!ct 6.,$.TR&-V,=+.RVs	]geometricVo%ner?	55 i/
c(ar	sense?	55 ic
s(ort	0o!n ar#?	55 in
!nion S4RF'-.V!	0len ?	55 i/

X?

t#/e ef str!ct :".+DV:,4+DVs]:".+DV:,4+D?

T(e s!//orting s!rface corres/on ing to t(e 0len V0o!n is

0len V0o!n -Z0len .0len e Ve ge-Zs!rfaceR1-0len V0o!n -Z0o!n ar#S.

4!!S)TDS7R!

'n offset s!rface is t(e res!lt of offsetting a s!rface a certain istance along its normal) ta3ing into acco!nt t(e s!rface sense. &t in(erits t(e /arameteriHation of t(is !n erl#ing s!rface.

!ie"d name	Data ty$e	Des#ri$tion
c(ec3	c(ar	c(ec3 stat!s
tr!eVoffset	logical	not !se
s!rface	/ointer	!n erl#ing s!rface
offset	o!0le	signe offset istance
scale	o!0le	for internal !se onl# Q ma# 0e set to n!ll

str!ct ,FFS.TVS4RFVs [['+9VS4RFVs 55 ,ffset s!rface

```
W
int                                 no eVi ?                    55 i
!nion 'TTR&:V6R,4PV!                attri0!tesVgro!/s?          55 i/
!nion S4RF'-.V,=+.RV!               o%ner?                      55 i/
!nion S4RF'-.V!                     ne>t?                       55 i/
!nion S4RF'-.V!                     /revio!s?                   55 i/
str!ct 6.,$.TR&-V,=+.RVs            ]geometricVo%ner?           55 i/
c(ar                                sense?                      55 ic
c(ar                                c(ec3?                      55 ic
logical                             tr!eVoffset?                55 il
!nion S4RF'-.V!                     s!rface?                    55 i/
 o!0le                              offset?                     55 if
 o!0le                              scale?                      55 if
X?
t#/e ef str!ct ,FFS.TVS4RFVs ],FFS.TVS4RF?
```

T(e offset s!rface is s!07ect to t(e follo%ing restrictions*

- T(e offset istance m!st not 0e %it(in mo eller linear resol!tion of Hero
- T(e sense of t(e offset s!rface m!st 0e t(e same as t(at of t(e !n erl#ing s!rface
- ,ffset s!rfaces ma# not s(are a common !n erl#ing s!rface

T(e Uc(ec3N fiel ma# ta3e one of t(e follo%ing val!es*

```
const c(ar S-;Vvali      [ @V?      55 vali
const c(ar S-;Vinvali    [ @&?      55 invali
const c(ar S-;V!nc(ec3e  [ @4?      55 (as not 0een c(ec3e
```

.DS7R!*C)

Parasoli s!//orts :s/line c!rves in f!ll +4R:S format.

!ie"d name	Data ty$e	Des#ri$tion
n!r0s	/ointer	6eometric efinition
ata	/ointer0	'!>iliar# information

```
str!ct :VS4RF'-.Vs[[ '+9VS4RFVs                    55 : s!rface
    W
    int                                 no eVi ?                    55 i
    !nion 'TTR&:V6R,4PV!                attri0!tesVgro!/s?          55 i/
    !nion S4RF'-.V,=+.RV!               o%ner?                      55 i/
    !nion S4RF'-.V!                     ne>t?                       55 i/
    !nion S4RF'-.V!                     /revio!s?                   55 i/
    str!ct 6.,$.TR&-V,=+.RVs            ]geometricVo%ner?           55 i/
    c(ar                                sense?                      55 ic
    str!ct +4R:SVS4RFVs                 ]n!r0s?                     55 i/
    str!ct S4RF'-.VD'T'Vs               ] ata?                      55 i/
    X?
t#/e ef str!ct :VS4RF'-.Vs    ]:VS4RF'-.?
```

T(e ata store in an 8T file for a +4R:S s!rface is

!ie"d name	Data ty$e	Des#ri$tion
!V/erio ic	logical	tr!e if s!rface is /erio ic in ! /arameter
vV/erio ic	logical	tr!e if s!rface is /erio ic in v /arameter
!V egree	s(ort	! egree of t(e s!rface
vV egree	s(ort	v egree of t(e s!rface
nV!Vvertices	int	n!m0er of control vertices 1U/olesN2 in ! irection
nVvVvertices	int	n!m0er of control vertices 1U/olesN2 in v irection
!V3notVt#/e	0#te	form of ! 3not vector Q see I: c!rveK
vV3notVt#/e	0#te	form of v 3not vector
nV!V3nots	int	n!m0er of istinct ! 3nots
nVvV3nots	int	n!m0er of istinct v 3nots
rational	logical	tr!e if s!rface is rational
!Vclose	logical	tr!e if s!rface is close in !
vVclose	logical	tr!e if s!rface is close in v
s!rfaceVform	0#te	s(a/e of s!rface) if s/ecial
verte>V im	s(ort	imension of control vertices
0s/lineVvertices	/ointer	control vertices 1/oles2 no e
!V3notVm!lt	/ointer	m!lti/licities of ! 3not vector
vV3notVm!lt	/ointer	m!lti/licities of v 3not vector
!V3nots	/ointer	! 3not vector
vV3nots	/ointer	v 3not vector

T(e s!rface form en!m is efine 0elo%.

t#/e ef en!m

```
W
S-;V!nset [ 1)                55 4n3no%n
S-;Var0itrar# [ 2)            55 +o /artic!lar s(a/e
S-;V/lanar [ B)
S-;Vc#lin rical [ D)
S-;Vconical [ E)
S-;Vs/(erical [ F)
```

```
    S- ; Vtoroi al [ C)
    S- ; Vs!rfVofVrevol!tion [ 8)
    S- ; Vr!le  [ 9)
    S- ; VA!a ric [ 10)
    S- ; Vs%e/t [ 11
    X
  S- ; Vs!rfaceVformVt?

str!ct +4R:SVS4RFVs                    55 +4R:S s!rface
    W
    logical                  !V/erio ic?              55 il
    logical                  vV/erio ic?              55 il
    s(ort                    !V egree?                55 in
    s(ort                    vV egree?                55 in
    int                      nV!Vvertices?            55 i
    int                      nVvVvertices?            55 i
    S- ; V3notVt#/eVt        !V3notVt#/e?             55 i!
    S- ; V3notVt#/eVt        vV3notVt#/e?             55 i!
    int                      nV!V3nots?               55 i
    int                      nVvV3nots?               55 i
    logical                  rational?                55 il
    logical                  !Vclose ?                55 il
    logical                  vVclose ?                55 il
    S- ; Vs!rfaceVformVt     s!rfaceVform?            55 i!
    s(ort                    verte>V im?              55 in
    str!ct :SP"&+.VV.RT&-.SVs ]0s/lineVvertices?      55 i/
    str!ct <+,TV$4"TVs       ]!V3notVm!lt?            55 i/
    str!ct <+,TV$4"TVs       ]vV3notVm!lt?            55 i/
    str!ct <+,TVS.TVs        ]!V3nots?                55 i/
    str!ct <+,TVS.TVs        ]vV3nots?                55 i/
    X?
t#/e ef str!ct +4R:SVS4RFVs ]+4R:SVS4RF?
```

T(e UOs/lineVverticesN) U3notVsetN an U3notVm!ltN no es an t(e U3notVt#/eN en!m are escriOe in t(e oc!mentation for : - 4RV . .

T(e Us!rface ataN fiel in a : s!rface no e is a str!ct!re esigne to (ol a!>iliar# or U erive N ata aOo!t t(e s!rface* it is not a necessar# /art of t(e efinition of t(e : s!rface. &t ma# Oe n!ll) or t(e ma7orit# of its in ivi !al fiel s ma# Oe n!ll. &t is recommen e t(at it onl# Oe set O# Parasoli .

```
str!ct S4RF ' - . VD ' T ' Vs              55 a!>iliar# s!rface ata
    W
    interval                    originalV!int?              55 ii
    interval                    originalVvint?              55 ii
    interval                    e>ten e V!int?              55 ii
    interval                    e>ten e Vvint?              55 ii
    S - ; VselfVintVt           selfVint?                   55 i!
    c(ar                        originalV!Vstart?           55 ic
    c(ar                        originalV!Ven ?             55 ic
    c(ar                        originalVvVstart?           55 ic
    c(ar                        originalVvVen ?             55 ic
    c(ar                        e>ten e V!Vstart?           55 ic
    c(ar                        e>ten e V!Ven ?             55 ic
    c(ar                        e>ten e VvVstart?           55 ic
    c(ar                        e>ten e VvVen ?             55 ic
    c(ar                        anal#ticVformVt#/e?         55 ic
    c(ar                        s%e/tVformVt#/e?            55 ic
    c(ar                        s/!nVformVt#/e?             55 ic
    c(ar                        Olen VformVt#/e?            55 ic
    voi                         ]anal#ticVform?             55 i/
    voi                         ]s%e/tVform?                55 i/
    voi                         ]s/!nVform?                 55 i/
    voi                         ]Olen Vform?                55 i/
    X?
```

t#/e ef str!ct S4RF ' - . VD ' T ' Vs]S4RF ' - . VD ' T ' ?

T(e UoriginalVN an Ue>ten e VN /arameter intervals an corres/on ing c(aracter fiel s originalV!Vstart etc. are all connecte %it(Parasoli Ns a0ilit# to e>ten : s!rfaces %(en necessar# Q f!nctionalit# %(ic(is commonl# e>/loite in Ilocal o/erationK algorit(ms for e>am/le. T(is is one a!tomaticall# %it(o!t t(e nee for !ser intervention.

&n cases %(ere t(e reA!ire e>tension can 0e /erforme 0# a ing ro%s or col!mns of control /oints) t(en t(e n!r0s ata %ill 0e mo ifie accor ingl# Q t(is is referre to as an Ue>/licitN e>tension. &n some rational : s!rface cases) e>/licit e>tension is not /ossi0le - in t(ese cases) t(e s!rface %ill 0e Uim/licitl#N e>ten e . = (en a : s!rface is im/licitl# e>ten e) t(e n!r0s ata is not c(ange) 0!t it %ill 0e treate as 0eing larger 0# allo%ing o!t-of-range eval!ations on t(e s!rface. = (enever an e>/licit or im/licit e>tension ta3es /lace) it is reflecte in t(e follo%ing fiel s*

- IoriginalV!VintK an IoriginalVvVintK are t(e original vali /arameter ranges for a : s!rface 0efore it %as e>ten e
- Ie>ten e V!VintK an Ie>ten e VvVintK are t(e vali /arameter ranges for a : s!rface once it (as 0een e>ten e .

T(e c(aracter fiel s UoriginalV!VstartN etc. all refer to t(e stat!s of t(e corres/on ing /arameter 0o!n ar# of t(e s!rface 0efore or after an e>tension (as ta3en /lace. For : s!rfaces) t(e c(aracter can (ave one of t(e follo%ing val!es*

const c(ar S- ; V egenerate [@D@?	55	Degenerate e ge
const c(ar S- ; V/erio ic [@P@?	55	Perio ic /arameterisation
const c(ar S- ; V0o!n e [@:@?	55	Parameterisation 0o!n e
const c(ar S- ; Vclose [@-@?	55	- lose) 0!t not /erio ic

T(e se/arate fiel s originalV!Vstart an e>ten e V!Vstart etc. are necessar# 0eca!se an e>tension ma# ca!se t(e corres/on ing /arameter 0o!n ar# to 0ecome egenerate.

&f t(e s!rfaceV ata no e is /resent) t(en t(e originalV!Vint) originalVvVint) originalV!Vstart) originalV!Ven) originalVvVstart an originalVvVen fiel s s(o!l 0e set to t(eir a//ro/riate val!es. &f t(e s!rface (as not 0een e>ten e) t(e e>ten e V!Vint an e>ten e VvVint fiel s s(o!l contain n!ll) an t(e e>ten e V!Vstart etc. fiel s s(o!l contain

const c(ar S- ; V!nsetVc(ar [@d@? 55 generic !ninvestigate val!e

' s soon as an# /arameter 0o!n ar# of t(e s!rface is e>ten e) all t(e fiel s s(o!l 0e set) regar less of %(et(er t(e corres/on ing 0o!n ar# (as 0een affecte 0# t(e e>tension.

T(e S- ; VselfVintVt en!m is oc!mente in t(e corres/on ing c!rveV ata str!ct!re !n er : c!rve.

T(e Us%e/tVformVt#/eN) Us/!nVformVt#/eN an U0len VformVt#/eN c(aracters an t(e corres/on ing /ointers s%e/tVform) s/!nVform an 0len Vform) are for f!t!re !se an are not im/lemente in Parasoli V12.0. T(e c(aracter fiel s s(o!l 0e set to S- ; V!nsetVc(ar 1UdN2 an t(e /ointers s(o!l 0e set to n!ll /ointer.

&f t(e anal#ticVform fiel is not n!ll) it %ill /oint to a ; . "&8VS4VF, R$ no e) %(ic(in icates t(at t(e s!rface (as a (elical s(a/e. &n t(is case t(e anal#ticVformVt#/e fiel %ill 0e set to U; N.

str!ct ; . "&8VS4VF, R$Vs

W

vector	a>isV/t	55 iv
vector	a>isV ir	55 iv
c(ar	(an	55 ic
interval	t!rns	55 ii
o!0le	/itc(	55 if
o!0le	ga/	55 if
o!0le	tol	55 if

X?

t#/e ef str!ct ; . "&8VS4VF, R$Vs]; . "&8VS4VF, R$?

T(e a>isV/t an a>isV ir fiel s efine t(e a>is of t(e (eli>. T(e (an fiel is U\N for a rig(t-(an e an U-N for a left-(an e (eli>. T(e t!rns fiel gives t(e e>tent of t(e (eli> relative to t(e /rofile c!rve %(ic(%as !se to generate t(e s!rface. For instance) an interval R0 10S in icates a start /osition at t(e /rofile c!rve an an en 10 t!rns along t(e a>is. Pitc(is t(e istance travelle along t(e a>is in one t!rn. Tol is t(e acc!rac# to %(ic(t(e o%ning 0s!rface fits t(is s/ecification. 6a/ is for f!t!re e>/ansion an %ill c!rrentl# 0e Hero. T(e v /arameter increases in t(e irection of t(e a>is.

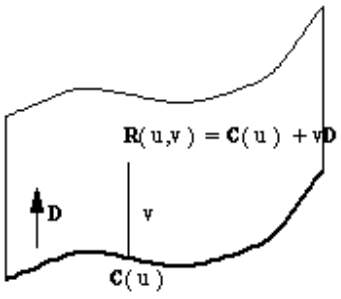
SW)3TDS7R!

' s%e/t s!rface (as a /arametric re/resentation of t(e form*

R1!)v2[-1!2\vD

%(ere

- -1!2 is t(e section c!rve.
- D is t(e s%ee/ irection 1!nit vector2.



- - m!st not 0e an intersection c!rve or a trimme c!rve.

!ie"d name	Data ty$e	Des#ri$tion
section	/ointer	section c!rve
s%ee/	vector	s%ee/ irection 1a !nit vector2
scale	o!0le	for internal !se onl# Q ma# 0e set to n!ll

str!ct S= .PTVS4RFVs [['+9VS4RFVs 55 S%e/t s!rface

W

int	no eVi ?	55 i
!nion 'TTR&:V6R,4PV!	attri0!tesVgro!/s?	55 i/
!nion S4RF'-.V,=+.RV!	o%ner?	55 i/
!nion S4RF'-.V!	ne>t?	55 i/
!nion S4RF'-.V!	/revio!s?	55 i/
str!ct 6.,$.TR&-V,=+.RVs	]geometricVo%ner?	55 i/
c(ar	sense?	55 ic
!nion -4RV.V!	section?	55 i/
vector	s%ee/?	55 iv
o!0le	scale?	55 if

X?

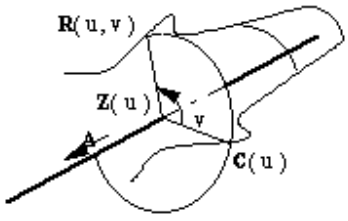
t#/e ef str!ct S= .PTVS4RFVs]S= .PTVS4RF?

S37NDS7R!

's/!n s!rface (as a /arametric re/resentation of t(e form*

R1!) v2 [L1!2 \ 1 -1!2 - L1!22cos1 v2 \ '8 1 -1!2 - L1!22 sin1 v2

%(ere



- -1!2 is t(e /rofile c!rve

- L1!2 is t(e /ro7ection of -1!2 onto t(e s/in a>is
- ' is t(e s/in a>is irection 1!nit vector2
- - m!st not 0e an intersection c!rve or a trimme c!rve

+ , T . * L1!2 [P \ 1 1 -1 ! 2 - P 2 . ' 2 ' %(ere P is a reference /oint on t(e a>is.

!ie"d name	Data ty$e	De2

vector	>Va>is?	55 iv
o!Ole	scale?	55 if

X?

t#/e ef str!ct SP4+VS4RFVs]SP4+VS4RF?

T(e UstartN an Uen N vectors corres/on to /(#sical egeneracies on t(e s/!n s!rface ca!se O# t(e /rofile c!rve crossing t(e s/in a>is at t(at /oint. T(e val!es startV/aram an en V/aram are t(e corres/on ing /arameters on t(e c!rve. T(ese /arameter val!es efine t(e vali range for t(e ! /arameter of t(e s!rface. &f eit(er val!e is n!ll) t(en t(e vali range for ! is infinite in t(at irection. For e>am/le) for a straig(t line /rofile c!rve intersecting t(e s/in a>is at t(e /arameter t[1) val!es of n!ll for startV/aram an 1 for en V/aram %o!l efine a cone %it(! /arameterisation 1-infinit#) 1S.

&f t(e /rofile c!rve lies in a /lane containing t(e s/in a>is) t(en >Va>is m!st Oe set to a vector /er/en ic!lar to t(e s/in a>is an in t(e /lane of t(e /rofile) /ointing from t(e s/in a>is to a /oint on t(e /rofile c!rve in t(e vali range. &f t(e /rofile c!rve is not /lanar) or its /lane oes not contain t(e s/in a>is) t(en >Va>is s(o!l Oe set to n!ll.

3) DS7R! B!orei n 1eometry s&r>a#eC

Foreign 1or UP.N2 geometr# in Parasoli is a t#/e !se for re/resenting c!stomersN in-(o!se /ro/rietar# ata. &t can also Oe !se internall# for re/resenting geometr# connecte %it(t(is ata 1for e>am/le) offset foreign s!rfaces2. T(ese t%o t#/es of foreign geometr# !sage are referre to as Ue>ternalN an UinternalN res/ectivel#. T(e onl# internal P. s!rface is t(e offset P. s!rface.

' //lications not !sing foreign geometr# %ill never enco!nter eit(er e>ternal or internal P. ata str!ct!res at Parasoli V9 or Oe#on .

!ie"d name	Data ty$e	Des#ri$tion

```
      str!ct 6. , $ .TR&-V , = + .RVs      ]geometricVo%ner?                55 i /
      c(ar                                 sense?                           55 ic
      c(ar                                 t#/e?                            55 ic
      !nion P.VD'T'V!                      ata?                             55 i /
      str!ct TR' +SF , R$Vs                ]tf?                             55 i /
      !nion P.V&+TV6. , $V!                internalVgeomR 1 S?              55 i /RS
      X?
t#/e ef str!ct P.VS4RFVs ]P.VS4RF?
T(e P.VD'T' an P.V&+TV6. , $ !nions are efine !n er UP. c!rveN.
```

Point

!ie"d name	Data ty$e	Des#ri$tion
no eVi	int	integer !niA!e %it(in /art
attri0!tesVgro!/s	/ointer0	attri0!tes an gro!/s associate %it(/oint
o%ner	/ointer	, %ner
ne>t	/ointer0	ne>t /oint in c(ain
/revio!s	/ointer0	/revio!s /oint in c(ain
/vec	vector	/osition of /oint

```
!nion P,&+TV, = + .RV!
      W
      str!ct V.RT.8Vs                  ]verte>?
      str!ct :,D9Vs                    ]0o #?
      str!ct 'SS.$:"9Vs                ]assem0l#?
      str!ct = ,R"DVs                  ]%orl ?
      X?

str!ct P,&+TVs                         55 Point
      W
      int                              no eVi ?                         55 i
      !nion 'TTR&:V6R,4PV!             attri0!tesVgro!/s?               55 i /
```

!nion P,&+TV, =+.RV!	o%ner?	55 i/
str!ct P,&+TVs	]ne>t?	55 i/
str!ct P,&+TVs	]/revio!s?	55 i/
vector	/vec?	55 iv

X?

t#/e ef str!ct P,&+TVs]P,&+T?

Transform

!ie"d name	Data ty$e	Des#ri$tion
no eVi	int	integer !niA!e %it(in /art
o%ner	/ointer	o%ning instance or %orl
ne>t	/ointer0	ne>t transform in c(ain
/revio!s	/ointer0	/revio!s /ointer in c(ain
rotationVmatri>	o!0leRBSRBS	rotation com/onent
translationVvector	vector	translation com/onent
scale	o!0le	scaling factor
flag	0#te	0inar# flags in icating non-trivial com/onents
/ers/ectiveVvector	vector	/ers/ective vector 1al%a#s n!ll vector2

T(e transform acts as

>N [1rotationVmatri> .> \ translationVvector2] scale

T(e UflagN fiel contains vario!s 0it flags %(ic(i entif# t(e com/onents of t(e transformation*

!"a Name	.inary :a"&e	Des#ri$tion
translation	00001	set if translation vector non-Hero
rotation	00010	set if rotation matri> is not t(e i entit#
scaling	00100	set if scaling com/onent is not 1.0
reflection	01000	set if eterminant of rotation matri> is negative
general affine	10000	set if t(e rotationVmatri> is not a rigi rotation

```
!nion TR ' +SF , R $ V , = + . RV!
    W
    str!ct &+ST ' + - . Vs          ]instance?
    str!ct = , R"DVs                ]%orl ?
    X?

str!ct TR ' +SF , R $ Vs            55 Transformation
    W
    int                             no eVi ?                    55 i
    !nion                           o%ner?                      55 i/
    TR ' +SF , R $ V , = + . RV!
    str!ct TR ' +SF , R $ Vs        ]ne>t?                      55 i/
    str!ct TR ' +SF , R $ Vs        ]/revio!s?                  55 i/
     o!Ole                          rotationVmatri>RBSRBS?      55 ifR9S
    vector                          translationVvector?         55 iv
     o!Ole                          scale?                      55 if
    !nsigne                         flag?                       55 i
    vector                          /ers/ectiveVvector?         55 iv
    X?
t#/e ef str!ct TR ' +SF , R $ Vs ]TR ' +SF , R $ ?
```

'ur(e and Surface Senses

T(e Unat!ralN tangent to a c!rve is t(at in t(e increasing /arameter irection) an t(e Unat!ralN normal to a s!rface is in t(e irection of t(e cross-/ro !ct of P5 ! an P5 v. For some /!r/oses t(ese are mo ifie 0# t(e c!rve an s!rface

$eometric)owner

=(ere geometr# (as e/en ants) t(e e/en ants /oint 0ac3 to t(e referencing geometr# 0# means of 6eometric ,%ner no es. .ac(geometric no e /oints to a o!0l#-lin3e ring of 6eometric ,%ner no es %(ic(i entif# its referencing geometr#. Reference geometr# is as follo%s*

&ntersection*	2 s!rfaces
SP-c!rve*	S!rface
Trimme c!rve*	0asis c!rve
:len e e ge*	2 s!//orting s!rfaces) 2 0len V0o!n s!rfaces) 1 s/ine c!rve
:len 0o!n *	0len s!rface
,ffset s!rface*	!n erl#ing s!rface
S%e/t s!rface*	section c!rve
S/!n s!rface*	/rofile c!rve

+ote t(at t(e 2D :-c!rve reference 0# an SP-c!rve is not a e/en ent in t(is sense) an oes not nee a geometric o%ner no e.

•

• !ie"d name	• Dat a ty$e	• Des#ri$tion
• o%ner	• /oin ter	• referencing geometr#
• ne>t	• /oin ter	• ne>t in ring of geometric o%ners referring to t(e same geometr#
• /revio!s	• /oin ter	• /revio!s in a0ove ring
• s(are Vgeome tr#	• /oin ter	• reference 1 e/en ent2 geometr#

•

str!ct 6.,$.TR&-V,=+.RVs 55 geometric o%ner of geometr#

W

!nion 6.,$.TR9V!	o%ner?	55 i/
str!ct 6.,$.TR&-V,=+.RVs	]ne>t?	55 i/
str!ct 6.,$.TR&-V,=+.RVs	]/revio!s?	55 i/

!nion 6 . , $. TR9V! s(are Vgeometr#? 55 i /

X?

t#/e ef str!ct 6 . , $. TR&-V , = + . RVs]6 . , $. TR&-V , = + . R?

Topology

&n t(e follo%ing ta0les) UignoreN means t(is ma# 0e set to n!ll 1Hero2 if an 8T file is create o!tsi e Parasoli . For an 8T file create 0# Parasoli) t(is ma# ta3e an# val!e) 0!t s(o!l 0e ignore .

4nless ot(er%ise state) all c(ains of no es are o!0l#-lin3e an n!ll-terminate .

- W4R,D

• !ie"d name	• Ty$e	• Des#ri$tion
• assem0l#	• /ointer0	• ;ea of c(ain of assem0lies
• attri0!te	• /ointer0	• &gnore
• 0o #	• /ointer0	• ;ea of c(ain of 0o ies
• transform	• /ointer0	• ;ea of c(ain of transforms
• s!rface	• /ointer0	• ;ea of c(ain of s!rfaces
• c!rve	• /ointer0	• ;ea of c(ain of c!rves
• /oint	• /ointer0	• ;ea of c(ain of /oints
• alive	• logical	• Tr!e !nless /artition is at initial /mar3
• attri0V ef	• /ointer0	• ;ea of c(ain of attri0!te efinitions
• (ig(estVi	• int	• ;ig(est /mar3 i in /artition
• c!rrentVi	• int	• & of c!rrent /mar3
• in e>Vma/Voffset	• int	• $!st 0e set to 0
• in e>Vma/	• /ointer0	• $!st 0e set to n!ll
• sc(emaVem0e ingVm a/	• /ointer0	• $!st 0e set to n!ll

•

T(e =orl no e is onl# !se %(en a /artition is transmitte . :eca!se some of t(e attri0!te efinitions ma# 0e reference 0# no es %(ic((ave 0een elete) 0!t %(ic(ma# rea//ear on roll0ac3) t(e attri0!te efinitions are c(aine off t(e =orl no e rat(er t(an sim/l# 0eing reference 0# attri0!tes.

T(e fiel s in e>Vma/Voffset) in e>Vma/) an sc(emaVem0e ingVma/ are !se for &n e>e Transmit? a//lications %riting 8T ata m!st set t(em to 0 an n!ll.

str!ct =,R"DVs 55 =orl

```
W
str!ct 'SS.$:"9Vs          ]assem0l#?          55 i/
str!ct 'TTR&:4T.Vs         ]attri0!te?         55 i/
str!ct :,D9Vs              ]0o #?              55 i/
str!ct TR'+SF,R$Vs         ]transform?         55 i/
!nion S4RF'-.V!            s!rface?            55 i/
!nion -4RV.V!              c!rve?              55 i/
str!ct P,&+TVs             ]/oint?             55 i/
logical                    alive?              55 il
str!ct 'TTR&:VD.FVs        ]attri0V ef?        55 i/
int                        (ig(estVi ?         55 i
int                        c!rrentVi ?         55 i
X?
t#/e ef str!ct =,R"DVs ]=,R"D?
```

***SS) 0 .,G**

(ig(estVno eVi	int	;ig(est no e-i in assem0l#
attri0!tesVgro!/s	/ointer0	;ea of c(ain of attri0!tes of) an gro!/s in) assem0l#
attri0!teVc(ains	/ointer0	"ist of attri0!tes) one for eac(attri0!te efinition !se in t(e assem0l#
list	/ointer0	+!ll
s!rface	/ointer0	;ea of constr!ction s!rface c(ain
c!rve	/ointer0	;ea of constr!ction c!rve c(ain
/oint	/ointer0	;ea of constr!ction /oint c(ain
3e#	/ointer0	&gnore
resVsiHe	o!0le	Val!e of UsiHe 0o>N %(en transmitte 1normall# 10002
resVlinear	o!0le	Val!e of mo eller linear /recision %(en transmitte 1normall# 1.0e-82.
refVinstance	/ointer0	;ea of c(ain of instances referencing t(is assem0l#
ne>t	/ointer0	&gnore
/revio!s	/ointer0	&gnore
state	0#te	Set to 1.

o%ner	/ointer0	&gnore
t#/e	0#te	' l%a#s 1.
s!0Vinstance	/ointer0	; ea of c(ain of instances in assem0l#

T(e val!e of t(e UstateN fiel s(o!l 0e ignore) as s(o!l an# no es of t#/e U< . 9N reference 0# t(e assem0l#. &f an 8T file is constr!cte o!tsi e Parasoli) t(e state fiel s(o!l 0e set to 1) an t(e 3e# to n!ll.

T(e (ig(estVno eVi gives t(e (ig(est no e-i of an# no e in t(e assem0l#. -ertain no es %it(in t(e assem0l# 1namel# instances) transforms) geometr#) attri0!tes an gro!/s2 (ave !niA!e no e-i s %(ic(are non-Hero integers.

t#/e ef en!m

```
W
S- ; Vcollective Vassem0l# [ 1)
S- ; Vcon7!nctive Vassem0l# [ 2)
S- ; V is7!nctive Vassem0l# [ B
X
S- ; Vassem0l#Vt#/e?
```

t#/e ef en!m

```
W
S- ; Vne%V/art [ 1)
S- ; Vstore V/art [ 2)
S- ; Vmo ifie V/art [ B)
S- ; Vanon#mo!sV/art [ D)
S- ; V!nloa e V/art [ E
X
S- ; V/art Vstate?
```

str!ct 'SS. $:"9Vs 55 'ssem0l#

```
W
int                          (ig(estVno eVi ?          55 i
!nion 'TTR&:V6R,4PV!         attri0!tesVgro!/s?        55 i/
```

```
      str!ct "&STVs                ]attri0!teVc(ains?                55 i/
      str!ct "&STVs                ]list?                            55 i/
      !nion S4RF'-.V!              s!rface?                          55 i/
      !nion -4RV.V!                c!rve?                            55 i/
      str!ct P,&+TVs               ]/oint?                           55 i/
      str!ct <.9Vs                 ]3e#?                             55 i/
       o!0le                       resVsiHe?                         55 if
       o!0le                       resVlinear?                       55 if
      str!ct &+ST'+-.Vs            ]refVinstance?                    55 i/
      str!ct 'SS.$:"9Vs            ]ne>t?                            55 i/
      str!ct 'SS.$:"9Vs            ]/revio!s?                        55 i/
      S-;V/artVstate               state?                            55 i!
      str!ct =,R"DVs               ]o%ner?                           55 i/
      S-;Vassem0l#Vt#/e            t#/e?                             55 i!
      str!ct &+ST'+-.Vs            ]s!0Vinstance?                    55 i/
      X?
t#/e ef str!ct 'SS.$:"9Vs ]'SS.$:"9?
str!ct <.9Vs                                    55 <e#
      W
      stringR1S?                   c(ar                              55 icRS
      X?
t#/e ef str!ct <.9Vs ]<.9?
```

-NST*NC)

!ie"d name	Ty$e	Des#ri$tion
no eVi	int	+o e-i
attri0!tesVgro!/s	/ointer0	;ea of c(ain of attri0!tes of instance an mem0erVofVgro!/s of instance
t#/e	0#te	'l%a#s 1
/art	/ointer	Part reference 0# instance
transform	/ointer0	Transform of instance
assem0l#	/ointer	'ssem0l# in %(ic(instance lies

ne>tVinV/art	/ointer0	+e>t instance in assem0l#
/revVinV/art	/ointer0	Previo!s instance in assem0l#
ne>tVofV/art	/ointer0	+e>t instance of instance-Z/art
/revVofV/art	/ointer0	Previo!s instance of instance-Z/art

```
t#/e ef en!m
    W
    S-;V/ositiveVinstance [ 1)
    S-;VnegativeVinstance [ 2
    X
    S-;VinstanceVt#/e?

!nion P'RTV!
    W
    str!ct :,D9Vs                ]0o #?
    str!ct 'SS.$:"9Vs            ]assem0l#?
    X?
t#/e ef !nion P'RTV!    P'RT?

str!ct &+ST'+-.Vs                55 &nstance
    W
    int                          no eVi ?                55 i
    !nion 'TTR&:V6R,4PV!         attri0!tesVgro!/s?      55 i/
    S-;VinstanceVt#/e            t#/e?                   55 i!
    !nion P'RTV!                 /art?                   55 i/
    str!ct TR'+SF,R$Vs           ]transform?             55 i/
    str!ct 'SS.$:"9Vs            ]assem0l#?              55 i/
    str!ct &+ST'+-.Vs            ]ne>tVinV/art?          55 i/
    str!ct &+ST'+-.Vs            ]/revVinV/art?          55 i/
    str!ct &+ST'+-.Vs            ]ne>tVofV/art?          55 i/
    str!ct &+ST'+-.Vs            ]/revVofV/art?          55 i/
    X?
```

t#/e ef str!ct &+ST ' + - . Vs]&+ST ' + - .?

. 4 DG

!ie"d name	Ty$e	Des#ri$tion
(ig(estVno eVi	int	; ig(est no e-i in 0o #
attri0!tesVgro!/s	/ointer0	; ea of c(ain of attri0!tes of) an gro!/s in) 0o #
attri0!teVc(ains	/ointer0	"ist of attri0!tes) one for eac(attri0!te efinition !se in t(e 0o #
s!rface	/ointer0	; ea of constr!ction s!rface c(ain
c!rve	/ointer0	; ea of constr!ction c!rve c(ain
/oint	/ointer0	; ea of constr!ction /oint c(ain
3e#	/ointer0	&gnore
resVsiHe	o!0le	Val!e of UsiHe 0o>N %(en transmitte 1normall# 10002
resVlinear	o!0le	Val!e of mo eller linear /recision %(en transmitte 1normall# 1.0e-82
refVinstance	/ointer0	; ea of c(ain of instances referencing t(is /art
ne>t	/ointer0	&gnore
/revio!s	/ointer0	&gnore
state	0#te	Set to 1 1see 0elo%2
o%ner	/ointer0	&gnore
0o #Vt#/e	0#te	: o # t#/e
nomVgeomVstate	0#te	Set to 1 1for f!t!re !se2
s(ell	/ointer0	For general 0o ies* n!ll For soli 0o ies* t(e first s(ell in one of t(e soli regions For ot(er 0o ies* t(e first s(ell in one of t(e regions T(is fiel is o2so"ete) an s(o!l 0e ignore 0# a//lications rea ing 8T files. = (en %riting 8T files) it m!st 0e set as a0ove.

0o!n ar#Vs!rface	/ointer0	;ea of c(ain of s!rfaces attac(e irectl# or in irectl# to faces or e ges or fins
0o!n ar#Vc!rve	/ointer0	;ea of c(ain of c!rves attac(e irectl# or in irectl# to e ges or faces or fins
0o!n ar#V/oint	/ointer0	;ea of c(ain of /oints attac(e to vertices
region	/ointer	;ea of c(ain of regions in 0o #? t(is is t(e infinite region
e ge	/ointer0	;ea of c(ain of all non-%ireframe e ges in 0o #
verte>	/ointer0	;ea of c(ain of all vertices in 0o #
in e>Vma/Voffset	int	$!st 0e set to 0
in e>Vma/	/ointer0	$!st 0e set to n!ll
no eVi Vin e>Vma/	/ointer0	$!st 0e set to n!ll
sc(emaVem0e ingVma/	/ointer0	$!st 0e set to n!ll

T(e val!e of t(e UstateN fiel s(o!l 0e ignore) as s(o!l an# no es of t#/e U<.9N reference 0# t(e 0o #. &f an 8T file is constr!cte o!tsi e Parasoli) t(e state fiel s(o!l 0e set to 1) an t(e 3e# to n!ll.

T(e (ig(estVno eVi gives t(e (ig(est no e of an# no e in t(is 0o #. $ost no es in a 0o # %(ic(are visi0le at t(e P< interface (ave no e-i s) %(ic(are non-Hero integers !niA!e to t(at no e %it(in t(e 0o #. ' //lications %riting 8T files m!st ens!re t(at no e-i s are /resent an istinct. T(e etails of %(ic(no es (ave no e i s are given in an a//en i>.

T(e fiel s in e>Vma/Voffset) in e>Vma/) no eVi Vin e>Vma/) an sc(emaVem0e ingVma/ are !se for &n e>e Transmit? a//lications %riting 8T files m!st ens!re t(at t(ese fiel s are set to 0 an n!ll.

t#/e ef en!m

W

S-;Vsoli V0o # [1)

S-;V%ireV0o # [2)

S-;Vs(eetV0o # [B)

S-;VgeneralV0o # [F

X

S-;V0o #Vt#/e?

t#/e ef s(ort s(ort en!m

```
        W
        S-;VnomVgeomVoff [ 1)          --- .ntirel# off
        S-;VnomVgeomVon  [ 2           --- .ntirel# on
        X
        S-;VnomVgeomVstateVt?

str!ct :,D9Vs                          55 :o #
      W
      int                              (ig(estVno eVi ?                55 i
      !nion 'TTR&:V6R,4PV!             attri0!tesVgro!/s?              55 i/
      str!ct "&STVs                    ]attri0!teVc(ains?              55 i/
      !nion S4RF'-.V!                  s!rface?                        55 i/
      !nion -4RV.V!                    c!rve?                          55 i/
      str!ct P,&+TVs                   ]/oint?                         55 i/
      str!ct <.9Vs                     ]3e#?                           55 i/
       o!0le                           resVsiHe?                       55 if
       o!0le                           resVlinear?                     55 if
      str!ct &+ST'+-.Vs                ]refVinstance?                  55 i/
      str!ct :,D9Vs                    ]ne>t?                          55 i/
      str!ct :,D9Vs                    ]/revio!s?                      55 i/
      S-;V/artVstate                   state?                          55 i!
      str!ct =,R"DVs                   ]o%ner?                         55 i/
      S-;V0o #Vt#/e                    0o #Vt#/e?                      55 i!
      S-;VnomVgeomVstateVt             nomVgeomVstate?                 55 i!
      str!ct S;."""Vs                  ]s(ell?                         55 i/
      !nion S4RF'-.V!                  0o!n ar#Vs!rface?               55 i/
      !nion -4RV.V!                    0o!n ar#Vc!rve?                 55 i/
      str!ct P,&+TVs                   ]0o!n ar#V/oint?                55 i/
      str!ct R.6&,+Vs                  ]region?                        55 i/
      str!ct .D6.Vs                    ]e ge?                          55 i/
      str!ct V.RT.8Vs                  ]verte>?                        55 i/
      int                              in e>Vma/Voffset?               55 i
      str!ct &+TVV'"4.SVs              ]in e>Vma/?                     55 i/
```

```
    str!ct&+TVV'"4.SVs          ]no eVi Vin e>Vma/?                55 i/
    str!ct&+TVV'"4.SVs          ]sc(emaVem0e  ingVma/?             55 i/
    X?
t#/e ef str!ct :,D9Vs   ]:,D9?
```

***tta#hin 1eometry to To$o"o y**

T(e faces %(ic(reference a s!rface are c(aine toget(er) s!rface-Zo%ner is t(e (ea of t(is c(ain. Similarl# t(e e ges %(ic(reference t(e same c!rve are c(aine toget(er. Fins o not s(are c!rves.

6eometr# in /arts ma# 0e c(aine into one of t(e t(ree 0o!n ar# geometr# c(ains) or one of t(e t(ree constr!ction geometr# c(ains. ' geometric no e %ill fall into one of t(e follo%ing cases*

1eometry	4wner	Whether #hained
' ttac(e to face	face	&n 0o!n ar#Vs!rface c(ain
' ttac(e to e ge or fin	e ge or fin	&n 0o!n ar#Vc!rve c(ain
' ttac(e to verte>	verte>	&n 0o!n ar#V/oint c(ain
&n irectl# attac(e to face or e ge or fin	0o #	&n 0o!n ar#Vs!rface c(ain or 0o!n ar#Vc!rve c(ain
-onstr!ction geometr#	0o # or assem0l#	&n s!rface) c!rve or /oint c(ain
2D :-c!rve in SP-c!rve	n!ll	+ot c(aine

;ere Uin irectl# attac(e N means geometr# %(ic(is a e/en ent of a e/en ent of 1... etc2 of geometr# attac(e to an e ge) face or fin.

6eometr# in a constr!ction c(ain ma# reference geometr# in a 0o!n ar# c(ain) 0!t not vice-versa.

R) 1-4N

!ie"d name	Ty$e	Des#ri$tion
no eVi	int	+o e-i
attri0!tesVgro!/s	/ointer0	;ea of c(ain of attri0!tes of region an mem0erVofVgro!/s of region
0o #	/ointer	:o # of region
ne>t	/ointer0	+e>t region in 0o #
/rev	/ointer0	Previo!s region in 0o #
s(ell	/ointer0	;ea of singl#-lin3e c(ain of s(ells in region
t#/e	c(ar	Region t#/e Q soli 1USN2 or voi 1UVN2

```
str!ct R.6&,+Vs                    55 Region
    W
    int                            no eVi ?                    55 i
    !nion 'TTR&:V6R,4PV!           attri0!tesVgro!/s?          55 i/
    str!ct :,D9Vs                  ]0o #?                      55 i/
    str!ct R.6&,+Vs                ]ne>t?                      55 i/
    str!ct R.6&,+Vs                ]/revio!s?                  55 i/
    str!ct S;."'Vs                 ]s(ell?                     55 i/
    c(ar                           t#/e?                       55 ic
    X?
t#/e ef str!ct R.6&,+Vs ]R.6&,+?
```

S**6),,**

!ie"d name	Ty$e	Des#ri$tion
no eVi	int	+o e-i
attri0!tesVgro!/s	/ointer0	;ea of c(ain of attri0!tes of s(ell
0o #	/ointer0	For s(ells in %ire an s(eet 0o ies) an for s(ells 0o!n ing a soli region of a soli 0o #) t(is is set to t(e 0o # of t(e s(ell. For s(ells in general 0o ies) or voi s(ells in soli 0o ies) it is n!ll. T(is fiel is o2so"ete) an s(o!l 0e ignore 0# a//lications rea ing 8T files. =(en %riting 8T files) it m!st 0e set as a0ove.
ne>t	/ointer0	+e>t s(ell in region
face	/ointer0	;ea of c(ain of 0ac3-faces of s(ell 1i.e. faces %it(face normal /ointing o!t of region of s(ell2.
e ge	/ointer0	;ea of c(ain of %ire-frame e ges of s(ell
verte>	/ointer0	&f s(ell consists of a single verte>) t(is is it? else n!ll
region	/ointer	Region of s(ell
frontVface	/ointer0	;ea of c(ain of front-faces of s(ell 1i.e. faces %it(face normal /ointing into region of s(ell2

```
str!ct S;."'Vs                     55 S(ell
```

```
W
int                              no eVi ?                    55 i
!nion 'TTR&:V6R,4PV!             attri0!tesVgro!/s?          55 i/
str!ct :,D9Vs                    ]0o #?                      55 i/
str!ct S;."Vs                    ]ne>t?                      55 i/
str!ct F'-.Vs                    ]face?                      55 i/
str!ct .D6.Vs                    ]e ge?                      55 i/
str!ct V.RT.8Vs                  ]verte>?                    55 i/
str!ct R.6&,+Vs                  ]region?                    55 i/
str!ct F'-.Vs                    ]frontVface?                55 i/
X?
t#/e ef str!ct S;."Vs  ]S;."?
```

!*C)

!ie"d name	Ty$e	Des#ri$tion
no eVi	int	+o e-i
attri0!tesVgro!/s	/ointer0	;ea of c(ain of attri0!tes of face an mem0erVofVgro!/s of face
tolerance	o!0le	+ot !se 1n!ll o!0le2
ne>t	/ointer0	+e>t 0ac3-face in s(ell
/revio!s	/ointer0	Previo!s 0ac3-face in s(ell
loo/	/ointer0	;ea of singl#-lin3e c(ain of loo/s
s(ell	/ointer	S(ell of %(ic(t(is is a 0ac3-face
s!rface	/ointer0	S!rface of face
sense	c(ar	Face sense Q /ositive 1U\N2 or negative 1U-N2
ne>tVonVs!rface	/ointer0	+e>t in c(ain of faces s(aring t(e s!rface of t(is face
/revio!sVonVs!rface	/ointer0	Previo!s in c(ain of faces s(aring t(e s!rface of t(is face
ne>tVfront	/ointer0	+e>t front-face in s(ell
/revio!sVfront	/ointer0	Previo!s front-face in s(ell
frontVs(ell	/ointer	S(ell of %(ic(t(is is a front-face

```
str!ct F ' - . Vs                    55 Face
    W
    int                              no eVi ?                    55 i
    !nion 'TTR&:V6R,4PV!             attri0!tesVgro!/s?          55 i/
     o!0le                           tolerance?                  55 if
    str!ct F ' - . Vs                ]ne>t?                      55 i/
    str!ct F ' - . Vs                ]/revio!s?                  55 i/
    str!ct " , , PVs                 ]loo/?                      55 i/
    str!ct S ; . "" Vs               ]s(ell?                     55 i/
    !nion S4RF ' - . V!              s!rface?                    55 i/
    c(ar                             sense?                      55 ic
    str!ct F ' - . Vs                ]ne>tVonVs!rface?           55 i/
    str!ct F ' - . Vs                ]/revio!sVonVs!rface?       55 i/
    str!ct F ' - . Vs                ]ne>tVfront?                55 i/
    str!ct F ' - . Vs                ]/revio!sVfront?            55 i/
    str!ct S ; . "" Vs               ]frontVs(ell?               55 i/
    X?
t#/e ef str!ct F ' - . Vs   ]F ' - .?
```

,443

!ie"d name	Ty$e	Des#ri$tion
no eVi	int	+o e-i
attri0!tesVgro!/s	/ointer0	;ea of c(ain of attri0!tes of loo/
fin	/ointer	,ne of ring of fins of loo/
face	/ointer	Face of loo/
ne>t	/ointer0	+e>t loo/ in face

- -so"ated ,oo$s

'n isolate loo/ 1one consisting of a single verte>2 oes not refer irectl# to a verte>) 0!t /oints to a fin %(ic(refers to t(at verte>. T(is isolate fin (as fin-Zfor%ar [fin-Z0ac3%ar [fin) an fin-Zot(er [fin-Zc!rve [fin-Ze ge [n!ll. &ts sense is not significant. T(e fin is c(aine into t(e c(ain of fins referencing t(e isolate verte>.

```
str!ct " , , PVs                    55 "oo/
    W
    int                               no eVi ?                    55 i
    !nion 'TTR&:V6R , 4PV!            attri0!tesVgro!/s?          55 i/
    str!ct F&+Vs                      ]fin?                       55 i/
    str!ct F' - .Vs                   ]face?                      55 i/
    str!ct " , , PVs                  ]ne>t?                      55 i/
    X?
t#/e ef str!ct " , , PVs   ]" , , P?
```

!-N

!ie"d name	Ty$e	Des#ri$tion
attri0!tesVgro!/s	/ointer0	;ea of c(ain of attri0!tes of fin
loo/	/ointer0	"oo/ of fin
for%ar	/ointer0	+e>t fin aro!n loo/
0ac3%ar	/ointer0	Previo!s fin aro!n loo/
verte>	/ointer0	For%ar verte> of fin
ot(er	/ointer0	+e>t fin aro!n e ge) cloc3%ise loo3ing along e ge
e ge	/ointer0	. ge of fin
c!rve	/ointer0	For a non- !mm# fin of a tolerant e ge) t(is %ill 0e a trimme SP-c!rve) ot(er%ise n!ll.
ne>tVatVv>	/ointer0	+e>t fin referencing t(e verte> of t(is fin
sense	c(ar	Positive 1U\N2 if t(e fin irection is /arallel to t(at of its e ge) else negative 1U-N2

D&mmy !ins

'n a//lication %ill see e ges as (aving an# n!m0er of fins) incl! ing Hero. ;o%ever internall#) t(e# (ave at least t%o. T(is is so t(at t(e for%ar an 0ac3%ar vertices of an e ge can al%a#s 0e fo!n as e ge-Zfin-Zverte> an e ge-Zfin-Zot(er-Zverte> res/ectivel# - t(e first one 0eing a /ositive fin) t(e secon a negative fin. &f an e ge oes not (ave 0ot(a /ositive an a negative e>ternall#-visi0le fin) d&mmy fins %ill e>ist for t(is /!r/ose. D!mm# fins (ave fin-Zloo/ [fin-Zfor%ar [fin-Z0ac3%ar [fin-Zc!rve [fin-Zne>tVatVv> [n!ll. For e>am/le t(e 0o!n aries of a s(eet al%a#s (ave one !mm# fin.

```
str!ct F&+Vs                          55 Fin
    W
    !nion  'TTR&:V6R,4PV!     attri0!tesVgro!/s?          55 i/
    str!ct ",,PVs             ]loo/?                      55 i/
    str!ct F&+Vs              ]for%ar ?                   55 i/
    str!ct F&+Vs              ]0ac3%ar ?                  55 i/
    str!ct V.RT.8Vs           ]verte>?                    55 i/
    str!ct F&+Vs              ]ot(er?                     55 i/
    str!ct .D6.Vs             ]e ge?                      55 i/
    !nion -4RV.V!             c!rve?                      55 i/
    str!ct F&+Vs              ]ne>tVatVv>?                55 i/
    c(ar                      sense?                      55 ic
    X?
t#/e ef str!ct F&+Vs ]F&+?
```

:)RT)O

!ie"d name	Ty$e	Des#ri$tion
no eVi	int	+o e-i
attri0!tesVgro!/s	/ointer0	;ea of c(ain of attri0!tes of verte> an mem0erVofVgro!/s of verte>
fin	/ointer0	;ea of singl#-lin3e c(ain of fins referencing t(is verte>
/revio!s	/ointer0	Previo!s verte> in 0o #
ne>t	/ointer0	+e>t verte> in 0o #
/oint	/ointer	Point of verte>
tolerance	o!0le	Tolerance of verte> 1n!ll- o!0le for acc!rate verte>2
o%ner	/ointer	,%ning 0o #1for non-acorn vertices2 or s(ell 1for acorn vertices2

```
!nion S;."",RV:,D9V!
    1
    str!ct :,D9Vs             ]0o #?
```

```
      str!ct S ; . ""Vs                    ]s(ell?
      X?
t#/e  ef !nion S ; . ""V , RV : , D9V! S ; . ""V , RV : , D9?

str!ct V . RT . 8Vs                        55 Verte>
      W
      int                                  no eVi ?                    55 i
      !nion  'TTR& : V6R , 4PV!            attri0!tesVgro! /s?         55 i /
      str!ct F&+Vs                         ]fin?                       55 i /
      str!ct V . RT . 8Vs                  ] /revio!s?                 55 i /
      str!ct V . RT . 8Vs                  ]ne>t?                      55 i /
      str!ct P , &+TVs                     ] /oint?                    55 i /
       o!0le                               tolerance?                  55 if
      !nion  S ; . ""V , RV : , D9V!       o%ner?                      55 i /
      X?
t#/e  ef str!ct V . RT . 8Vs  ]V . RT . 8?
```

)D1)

!ie"d name	Ty$e	Des#ri$tion
no eVi	int	+o e-i
attri0!tesVgro! /s	/ointer0	; ea of c(ain of attri0!tes of e ge an mem0erVofVgro! /s of e ge
tolerance	o!0le	Tolerance of e ge 1n!ll- o!0le for acc!rate e ges2
fin	/ointer	, ne of singl#-lin3e ring of fins aro!n e ge
/revio!s	/ointer0	Previo!s e ge in 0o # or s(ell
ne>t	/ointer0	+e>t e ge in 0o # or s(ell
c!rve	/ointer0	- !rve of e ge) Hero for tolerant e ge. &f e ge is acc!rate) 0!t an# of its vertices are tolerant) t(is %ill 0e a trimme c!rve
ne>tVonVc!rve	/ointer0	+e>t in c(ain of e ges s(aring t(e c!rve of t(is e ge
/revio!sVonVc!rve	/ointer0	Previo!s in c(ain of e ges s(aring t(e c!rve of t(is e ge

o%ner	/ointer	, %ning 0o # 1for non-%ireframe e ges2 or s(ell 1for %ireframe e ges2

```
str!ct .D6.Vs                          55 . ge
    W
    int                                no eVi ?                          55 i
    !nion 'TTR&:V6R,4PV!               attri0!tesVgro!/s?                55 i/
     o!0le                             tolerance?                        55 if
    str!ct F&+Vs                       ]fin?                             55 i/
    str!ct .D6.Vs                      ]/revio!s?                        55 i/
    str!ct .D6.Vs                      ]ne>t?                            55 i/
    !nion -4RV.V!                      c!rve?                            55 i/
    str!ct .D6.Vs?                     ]ne>tVonVc!rve                    55 i/
    str!ct .D6.Vs                      ]/revio!sVonVc!rve?               55 i/
    !nion                              o%ner?                            55 i/
    S;.""V,RV:,D9V!
    X?
t#/e ef str!ct .D6.Vs  ].D6.?
```

Associated Data

,-ST

!ie"d name	Ty$e	Des#ri$tion
no eVi	int	Lero
listVt#/e	0#te	' l%a#s D
notransmit	logical	&gnore
o%ner	/ointer	, %ning /art
ne>t	/ointer0	&gnore
/revio!s	/ointer0	&gnore
listVlengt(	int	"engt(of list 1 Z[02
0loc3Vlengt(	int	"engt(of eac(0loc3 of list. ' l%a#s 20
siHeVofVentr#	int	&gnore
fingerVin e>	int	' n# integer 0et%een 1 an list-ZlistVlengt(1set to 1 if lengt(is Hero2. &gnore
fingerV0loc3	/ointer	' n# 0loc3 e.g. t(e first one. &gnore
listV0loc3	/ointer	; ea of singl#-lin3e c(ain of /ointer list 0loc3s

"ists onl# occ!r in /art files as t(e list of attri0!tes reference 0# a /art.

t#/e ef en!m

W

"&SV/ointer [D

X

"&SVt#/eVt?

!nion "&SV:", -<V!

W

str!ct P, &+T.RV"&SV:", -<Vs]/interV0loc3?

X?

t#/e ef !nion "&SV:", -<V! "&SV:", -<?

!nion "&STV, =+.RV!

```
W
str!ct : ,D9Vs                    ]0o #?
str!ct 'SS.$:"9Vs                 ]assem0l#?
str!ct = ,R"DVs                   ]%orl ?
X?
t#/e ef !nion "&STV, =+.RV! "&STV, =+.R?

str!ct "&STVs                     55 "ist ;ea er
W
int                               no eVi ?                    55 i
"&SVt#/eVt                        listVt#/e?                  55 i!
logica .
```

30029.0000744 1 Tcm3.04097 0 Tdm45.496814()-0.496814()-0.496814814()-0.46035()-0.49684(99()]TJm

= (en t(e /ointerVlisV0loc3 is !se as t(e root no e in a transmit file containing more t(an one /art) t(e restriction nVentries Y[20 oes not a//l#.

T(e in e>Vma/Voffset fiel is !se for &n e>e Transmit? a//lications %riting 8T files m!st ens!re t(is fiel is set to 0.

```
str!ct P , &+T . RV"&SV : " , - <Vs                55 Pointer "ist
      W
      int                                  nVentries?                  55 i
      int                                  in e>Vma/Voffset            55 i
      str!ct P , &+T . RV"&SV : " , - <Vs  ]ne>tV0loc3?                55 i/
      voi                                  ]entriesR 1 S?              55 i/RS
      X?
t#/e ef str!ct P , &+T . RV"&SV : " , - <Vs ]P , &+T . RV"&SV : " , - <?
```

***TTDD) !D-D**

!ie"d name	Ty$e	Des#ri$tion
stringRS	c(ar	String name e.g. bSD"5T9S 'V- , " , 4Rb

```
str!ct 'TTVD . FV&DVs          55 name fiel t#/e for attri0 ef.
      W
      c(ar                                 StringR1S?                  55 icRS
      X?
t#/e ef str!ct 'TTVD . FV&DVs ] 'TTVD . FV&D?
```

!-) , DDN* 0)S

!ie"d name	Ty$e	Des#ri$tion
namesRS	/ointer	'rra# of fiel names Q !nico e or c(ar

t#/e ef !nion F&. "DV+ ' $. V!

```
W
str!ct - ; ' RVV ' " 4 . SVs          ]name
str!ct 4 +& - , D . VV ' " 4 . SVs    ] ! name
X?
F& . " DV + ' $ . Vt?

str!ct F& . " DV + ' $ . Vs       55 attri0!te fiel  name
W
!nion F& . " DV + ' $ . V!              namesR1S?                    55 i/RS
X?
t#/e ef str!ct F& . " DV + ' $ . Vs ]F& . " DV + ' $ . ?
```

***TTR-.DD)!**

!ie"d name	Ty$e	Des#ri$tion
ne>t	/ointer0	+e>t attri0!te efinition. T(is can 0e ignore)e>ce/t in a /artition transmit file.
i entifier	/ointer	Pointer to string name
t#/eVi	int	+!meric i)e.g. 8001 for color. 9000 for !ser- efine attri0!te efinitions
actionsR8S	0#te	ReA!ire actions on vario!s events
fiel Vnames	/ointer0	+ames of fiel s 1!nico e or c(ar2
legalVo%nersR1DS	logical	'llo%e o%ner t#/es
fiel sRS	0#te	'rra# of fiel t#/es. +ote t(at t(e n!m0er of fiel s is given 0# t(e lengt(of t(e varia0le lengt(/art of t(is no e) i.e. t(e integer follo%ing t(e no e t#/e in t(e transmit file.

T(e legalVo%ners arra# is an arra# of logicals etermining %(ic(no e t#/es ma# o%n t(is t#/e of attri0!te.

e.g. if faces are allo%e attri0V ef -Z legalVo%ners RS - ; VfaVo%nerS [tr!e.

+ote t(at if t(e file contains !ser fiel s) t(e Ufiel sN fiel of an attri0!te efinition ma# contain e>tra val!es) set to Hero. T(ese are to 0e ignore .

T(e UactionsN fiel in an attri0!te efinition efines t(e 0e(avio!r of t(e attri0!te %(en an event 1rotate) scale) translate) reflect) s/lit) merge) transfer) c(ange2 occ!rs. T(e actions are*

oVnot(ing	"eave attri0!te as it is
elete	Delete t(e attri0!te
transform	Transform t(e transforma0le fiel s 1/oint) vector) irection) a>is2 0# a//ro/riate /art of transformation
/ro/agate	-o/# attri0!te onto s/lit-off no e
3ee/Vs!0V ominant	$ ove attri0!te1s2 from elete no e onto s!rviving no e in a merge) 0!t an# s!c(attri0!tes alrea # on t(e s!rviving no e are elete .
3ee/VifVeA!al	<ee/ attri0!te if /resent on 0ot(no es 0eing merge) %it(t(e same fiel val!es.
com0ine	$ ove attri0!te1s2 from elete no e onto s!rviving no e) in a merge

T(e P< attri0!te classes 1-C corres/on as follo%s*

	s/lit	merge	transfer	c(ange	Rotate	scale	translate	reflect
class 1	/ro/agate	3ee/VeA!al	oVnot(ing	oVnot(ing	oVnot(ing	oVnot(ing	oVnot(ing	oVnot(ing
class 2	elete	elete	elete	elete	oVnot(ing	elete	oVnot(ing	oVnot(ing
class B	elete	elete	elete	elete	Delete	elete	elete	elete
class D	/ro/agate	3ee/VeA!al	oVnot(ing	oVnot(ing	Transform	transform	transform	transform
class E	elete	elete	elete	elete	Transform	transform	transform	transform
class F	/ro/agate	com0ine	oVnot(ing	oVnot(ing	oVnot(ing	oVnot(ing	oVnot(ing	oVnot(ing
class C	/ro/agate	com0ine	oVnot(ing	oVnot(ing	Transform	transform	transform	transform

-ertain attri0!te efinitions are create 0# Parasoli on start!/) t(ese are oc!mente in an a//en i>.

t#/e ef en!m

W

S-;Vrotate [0)

S-;Vscale [1)

S-;Vtranslate [2)

S-;Vreflect [B)

S-;Vs/lit [D)

S- ; Vmerge [E)

S- ; Vtransfer [F)

S- ; Vc(ange [C)

S- ; Vma>Vlogge Vevent 55 last entr#? val!e in i RS co e for actions

X

S- ; Vlogge VeventVt?

t#/e ef en!m

W

S- ; V oVnot(ing [0)

S- ; V elete [1)

S- ; Vtransform [2)

S- ; V/ro/agate [B)

S- ; V3ee/Vs!OV ominant [D)

S- ; V3ee/VifVeA!al [E)

S- ; Vcom0ine [F

X

S- ; VactionVonVfiel sVt?

t#/e ef en!m

W

S- ; VasVo%ner [0)

S- ; VinVo%ner [1)

S- ; VO#Vo%ner [2)

S- ; Vs(Vo%ner [B)

S- ; VfaVo%ner [D)

S- ; VloVo%ner [E)

S- ; Ve Vo%ner [F)

S- ; Vv>Vo%ner [C)

S- ; VfeVo%ner [8)

S- ; VsfVo%ner [9)

```
S-;Vc!Vo%ner [ 10)
S-;V/tVo%ner [ 11)
S-;VrgVo%ner [ 12)
S-;VfnVo%ner [ 1B)
S-;Vma>Vo%ner                55 last entr#? val!e in i!RS for
                                .legalVo%ners
XS-;VattriOVo%nersVt?

t#/e ef en!m
W
S-;VintVfiel          [ 1)
S-;VrealVfiel         [ 2)
S-;Vc(arVfiel         [ B)
S-;V/ointVfiel        [ D)
S-;VvectorVfiel       [ E)
S-;V irectionVfiel    [ F)
S-;Va>isVfiel         [ C)
S-;VtagVfiel          [ 8)
S-;V/ointerVfiel      [ 9)
S-;V!nico eVfiel      [ 10
XS-;Vfiel Vt#/eVt?

str!ct 'TTR&:VD.FVs          55 attriO!te efinition
W
str!ct 'TTR&:VD.FVs          ]ne>t?                          55 i/
str!ct 'TTVD.FV&DVs          ]i entifier?                    55 i/
int                          t#/eVi ?                        55 i
S-;VactionVonVfiel sVt       actions                         55 i!R8S
                             R1int2S-;Vma>Vlogge VeventS?
str!ct F&."DV+' $.SVs        ]fiel Vnames                    55 i/
logical                      legalVo%ners                    55 i!R1DS
                             R1int2S-;Vma>Vo%nerS?
S-;Vfiel Vt#/eVt             fiel sR1S?                      55 i!RS
```

X?

t#/e ef str!ct 'TTR&:VD.FVs]'TTR&:VD.F?

*TTR-.7T)

!ie"d name	Ty$e	Des#ri$tion
no eVi	int	+o e-i
efinition	/ointer	'ttri0!te efinition
o%ner	/ointer	'ttri0!te o%ner
ne>t	/ointer0	+e>t attri0!te) gro!/) or mem0erVofVgro!/
/revio!s	/ointer0	Previo!s itto
ne>tVofVt#/e	/ointer0	+e>t attri0!te of t(is t#/e in t(is /art
/revio!sVofVt#/e	/ointer0	Previo!s attri0!te of t(is t#/e in t(is /art
fiel sRS	/ointer	Fiel s) of t#/e intVval!es etc. T(e n!m0er of fiel s is given 0# t(e lengt(of t(e varia0le /art of t(e no e. T(ere ma# 0e no fiel s.

T(e attri0!tes of a no e are c(aine !sing t(e ne>t an /revio!s /ointers in t(e attri0!te. T(e attri0!teVgro!/s /ointer in t(e no e /oints to t(e (ea of t(is c(ain. T(is c(ain also contains t(e mem0erVofVgro!/s of t(e no e.

'ttri0!tes %it(in t(e same /art) %it(t(e same attri0!te efinition) are c(aine toget(er 0# t(e ne>tVofVt#/e an /revio!sVofVt#/e /ointers. T(e /art /oints to t(e (ea of t(is c(ain as follo%s. T(e attri0!teVc(ains /ointer in t(e /art /oints to a list %(ic(contains t(e (ea s of t(ese attri0!te c(ains) one for eac(attri0!te efinition %(ic((as attri0!tes in t(e /art. T(e list ma# 0e n!ll.

+ote t(at t(e attri0!tesVgro!/s c(ains in /arts) gro!/s an no es contain t(e follo%ing t#/es of no e*

Part*	attri0!tes an gro!/s
6ro!/*	attri0!tes
+o e*	attri0!tes an mem0erVofVgro!/s

Fiel s of t#/e U/ointerN can 0e !se in Parasoli V12.0) 0!t t(e# are al%a#s transmitte as em/t#.

!nion 'TTR&:4T.V,=+.RV!

W

str!ct 'SS.$:"9Vs]assem0l#?

```
      str!ct &+ST ' + - . Vs          ]instance?
      str!ct : , D9Vs                 ]0o #?
      str!ct S ; . " "Vs              ]s(ell?
      str!ct R . 6& , +Vs             ]region?
      str!ct F ' - . Vs               ]face?
      str!ct " , , PVs                ]loo/?
      str!ct . D6 . Vs                ]e ge?
      str!ct F&+Vs                    ]fin?
      str!ct V . RT . 8Vs             ]verte>?
      !nion S4RF ' - . V!             S!rface?
      !nion - 4RV . V!                - !rve?
      str!ct P , &+TVs                ]/oint?
      str!ct 6R , 4PVs                ]gro!/?
      X?
t#/e ef !nion 'TTR&: 4T . V , = + . RV! 'TTR&: 4T . V , = + . R?

!nion F&. "DVV ' " 4 . SV!
      W
      str!ct &+TVV ' " 4 . SVs        ]intVval!es?
      str!ct R . ' "VV ' " 4 . SVs    ]realVval!es?
      str!ct - ; 'RVV ' " 4 . SVs     ]c(arVval!es?
      str!ct P , &+TVV ' " 4 . SVs    ]/ointVval!es?
      str!ct V . -T , RVV ' " 4 . SVs ]vectorVval!es?
      str!ct D&R . -T& , +VV ' " 4 . SVs ] irectionVval!es?
      str!ct ' 8&SVV ' " 4 . SVs      ]a>isVval!es?
      str!ct T ' 6VV ' " 4 . SVs      ]tagVval!es?
      str!ct 4 +&- , D . VV ' " 4 . SVs ]!nico eVval!es?
      X?
t#/e ef !nion F&. "DVV ' " 4 . SV! F&. "DVV ' " 4 . S?

str!ct 'TTR&: 4T . Vs                 55 'ttri0!te
      W
```

```
int                                 no eVi ?                    55 i
str!ct 'TTR&:VD.FVs                 ] efinition?                55 i/
!nion 'TTR&:4T.V,=+.RV!             o%ner?                      55 i/
!nion 'TTR&:V6R,4PV!                ne>t?                       55 i/
!nion 'TTR&:V6R,4PV!                /revio!s?                   55 i/
str!ct 'TTR&:4T.Vs                  ]ne>tVofVt#/e?              55 i/
str!ct 'TTR&:4T.Vs                  ]/revio!sVofVt#/e?          55 i/
!nion F&."DVV'"4.SV!                fiel sR1S?                  55 i/RS
X?
t#/e ef str!ct 'TTR&:4T.Vs ]'TTR&:4T.?
```

-NTD:*,7)S

val!esRS	int	&nteger val!es

```
str!ct &+TVV'"4.SVs                 55 &nt val!es
W
int                                 val!esR1S?                  55 i RS
X?
t#/e ef str!ct &+TVV'"4.SVs ]&+TVV'"4.S?
```

R)*,D:*,7)S

val!esRS	o!0le	Real val!es

```
str!ct R.'"VV'"4.SVs                55 Real val!es
W
 o!0le                              val!esR1S?                  55 ifRS
X?
t#/e ef str!ct R.'"VV'"4.SVs ]R.'"VV'"4.S?
```

C6*RD:*,7)S

vector val!esR1S? 55 ivRS

X?

t#/e ef str!ct V . -T , RVV ' " 4 . SVs]V . -T , RVV ' " 4 . S?

D-R)CT-4ND:*,7)S

val!esRS	vector	Direction val!es

str!ct D&R . -T& , +VV ' " 4 . SVs 55 Direction val!es

W

vector val!esR1S? 55 ivRS

X?

t#/e ef str!ct D&R . -T& , +VV ' " 4 . SVs]D&R . -T& , +VV ' " 4 . S?

***O-SD:*,7)**S

val!esRS	vector	' >is val!es

+ote t(at an a>is ta3es ! / t%o vectors.

str!ct ' 8&SVV ' " 4 . SVs 55 ' >is val!es

W

vector val!esR1S? 55 ivRS

X?

t#/e ef str!ct ' 8&SVV ' " 4 . SVs] ' 8&SVV ' " 4 . S?

T*1D:*,7)S

val!esRS	int	&nteger tag val!es

T(e tag fiel t#/e an t(e tagVval!es no e are not availa0le for !se in !ser- efine attri0!tes) t(e# occ!r onl# in certain s#stem attri0!tes.

str!ct T ' 6VV ' " 4 . SVs 55 Tag val!es

W

int val!esR1S? 55 itRS

X?

t#/e ef str!ct T ' 6VV ' " 4 . SVs]T ' 6VV ' " 4 . S?

1R4 7 3

!ie"d name	Ty$e	Des#ri$tion
no eVi	int	+o e-i
attri0!tesVgro!/s	/ointer0	; ea of c(ain of attri0!tes of t(is gro!/
o%ner	/ointer	, %ning /art
ne>t	/ointer0	+e>t gro!/ or attri0!te
/revio!s	/ointer0	Previo!s gro!/ or attri0!te
t#/e	0#te	T#/e of no e allo%e in gro!/
firstVmem0er	/ointer0	; ea of c(ain of mem0erVofVgro!/ no es in gro!/

T(e gro!/s in a /art are c(aine 0# t(e ne>t an /revio!s /ointers in a gro!/. T(e attri0!tesVgro!/s /ointer in t(e /art /oints to t(e (ea of t(e c(ain. T(is c(ain also contains t(e attri0!tes attac(e irectl# to t(e /art - gro!/s an attri0!tes are intermingle in t(is c(ain) t(e or er is not significant.

. ac(gro!/ (as a c(ain of mem0erVofVgro!/s. T(e ac2 8rev.io1S3V0mem0er/n-0i . 36 5 6(t(e an (a) t(e c(0is0a0 4e4i0erTV

```
S-;Vverte>Vfe     [ E)
S-;Vs!rfaceVfe    [ F)
S-;Vc!rveVfe      [ C)
S-;V/ointVfe      [ 8)
S-;Vmi>e Vfe      [ 9)
S-;VregionVfe     [ 10
X S-;Vgro!/Vt#/eVt?

str!ct 6R,4PVs                55 6ro!/
    W
    int                       no eVi ?                55 i
    !nion 'TTR&:V6R,4PV!      attri0!tesVgro!/s?      55 i/
    !nion P'RTV!              o%ner?                  55 i/
    !nion 'TTR&:V6R,4PV!      ne>t?                   55 i/
    !nion 'TTR&:V6R,4PV!      /revio!s?               55 i/
    S-;Vgro!/Vt#/eVt          t#/e?                   55 i!
    str!ct $.$:.RV,FV6R,4PVs  ]firstVmem0er?          55 i/
    X?
t#/e ef str!ct 6R,4PVs ]6R,4P?
```

0)0.)RD4!D1R473

!ie"d name	Ty$e	Des#ri$tion
!mm#Vno eVi	int	.ntit# la0el
o%ningVgro!/	/ointer	,%ning gro!/
o%ner	/ointer	Reference mem0er of gro!/
ne>t	/ointer0	+e>t attri0!te) gro!/ or mem0erVofVgro!/
/revio!s	/ointer0	Previo!s itto
ne>tVmem0er	/ointer0	+e>t mem0erVofVgro!/ in t(is gro!/
/revio!sVmem0er	/ointer0	Previo!s itto

```
!nion 6R,4PV$.$:.RV!
```

```
      W
      str!ct &+ST ' + - . Vs              ]instance?
      str!ct F ' - . Vs                   ]face?
      str!ct R . 6&, +Vs                  ]region?
      str!ct " , , PVs                    ]loo/?
      str!ct . D6 . Vs                    ]e ge?
      str!ct V . RT . 8Vs                 ]verte>?
      !nion S4RF ' - . V!                 s!rface?
      !nion - 4RV . V!                    c!rve?
      str!ct P , &+TVs                    ]/oint?
      X?
t#/e ef !nion 6R , 4PV $ . $ : . RV! 6R , 4PV $ . $ : . R?

str!ct $ . $ : . RV , FV6R , 4PVs         55 $em0er of gro!/
      W
      int                                   !mm#Vno eVi ?                 55 i
      str!ct 6R , 4PVs                     ]o%ningVgro!/?                 55 i/
      !nion 6R , 4PV $ . $ : . RV!         o%ner?                         55 i/
      !nion 'TTR&:V6R , 4PV!               ne>t?                          55 i/
      !nion 'TTR&:V6R , 4PV!               /revio!s?                      55 i/
      str!ct $ . $ : . RV , FV6R , 4PVs    ]ne>tVmem0er?                  55 i/
      str!ct $ . $ : . RV , FV6R , 4PVs    ]/revio!sVmem0er?              55 i/
      X?
t#/e ef str!ct $ . $ : . RV , FV6R , 4PVs ] $ . $ : . RV , FV6R , 4P?
```

Node Types

Node name	Node ty$e	: isi2"e at 3H	6as node/id
'SS.$:"9	10	9es	+o
&+ST'+-.	11	9es	9es
:,D9	12	9es	+o
S;.””	1B	9es	9es
F'-.	1D	9es	9es
",,P	1E	9es	9es
.D6.	1F	9es	9es
F&+	1C	9es	+o
V.RT.8	18	9es	9es
R.6&,+	19	9es	9es
P,&+T	29	9es	9es
"&+.	B0	9es	9es
-&R-".	B1	9es	9es
.""&PS.	B2	9es	9es
&+T.RS.-T&,+	B8	9es	9es
-;'RT	D0	+o	
"&$&T	D1	+o	
:SP"&+.VV.RT&-.S	DE	+o	
P"'+.	E0	9es	9es
-9"&+D.R	E1	9es	9es
-,+.	E2	9es	9es
SP;.R.	EB	9es	9es
T,R4S	ED	9es	9es

:". +D.DV.D6.	EF	9es	9es
:". +DV:,4+D	E9	+o	
,FFS.TVS4RF	F0	9es	9es
S=.PTVS4RF	FC	9es	9es
SP4+VS4RF	F8	9es	9es
"&ST	C0	9es	9es
P,&+T.RV"&SV:",-<	CD	+o	
'TTVD.FV&D	C9	+o	
'TTR&:VD.F	80	9es	+o
'TTR&:4T.	81	9es	9es
&+TVV'"4.S	82	+o	
R.'"VV'"4.S	8B	+o	
-;'RVV'"4.S	8D	+o	
P,&+TVV'"4.S	8E	+o	
V.-T,RVV'"4.S	8F	+o	
'8&SVV'"4.S	8C	+o	
T'6VV'"4.S	88	+o	
D&R.-T&,+VV'"4.S	89	+o	
6R,4P	90	9es	9es
$.$:.RV,FV6R,4P	91	+o	
4+&-,D.VV'"4.S	98	+o	
F&."DV+'$.S	99	+o	
TR'+SF,R$	100	9es	9es
=,R"D	101	+o	
<.9	102	+o	
P.VS4RF	120	9es	9es

&+TVP.VD'T'	121	+o	
.8TVP.VD'T'	122	+o	
:VS4RF'-.	12D	9es	9es
S4RF'-.VD'T'	12E	+o	
+4R:SVS4RF	12F	+o	
<+,TV$4"T	12C	+o	
<+,TVS.T	128	+o	
P.V-4RV.	1B0	9es	9es
TR&$$.DV-4RV.	1BB	9es	9es
:V-4RV.	1BD	9es	9es
-4RV.VD'T'	1BE	+o	
+4R:SV-4RV.	1BF	+o	
SPV-4RV.	1BC	9es	9es
6.,$.TR&-V,=+.R	1D1	+o	
;."&8V-4VF,R$	1FB	+o	
;."&8VS4VF,R$	18D	+o	

Node Classes

Node #"ass name	Node #"ass
6.,$.TR9	100B
P'RT	100E
S4RF'-.	100F
S4RF'-.V,=+.R	100C
-4RV.	1008
-4RV.V,=+.R	1010
P,&+TV,=+.R	1011
"&SV:",-<	1012
"&STV,=+.R	101B
'TTR&:4T.V,=+.R	101E
6R,4PV,=+.R	101F
6R,4PV$.$:.R	101C
F&."DVV'"4.S	1018
'TTR&:V6R,4P	1019
TR'+SF,R$V,=+.R	102B
P.VD'T'	102C
P.V&+TV6.,$	1028
S;."'V,RV:,D9	1029
F&."DV+'$.	10BC

System Attribute Definitions

' ll s#stem attri0!te efinitions are of class 1.

Hatching

-denti>ier	SD"5T9S'V; 'T-;&+6	
Ty$eDid	800B	
)ntity ty$es	face	
!ie"ds	real	real 1
		real 2
		real B
		real D
	integer	;atc(ing t#/e
Set 2y	' //lication	
7sed 2y	Parasoli (i en line an %ireframe images	

For $"anar hat#hin - t(e fo!r real val!es efine t(e (atc(orientation as a vector an a s/acing 0et%een consec!tive /lanes.

For radia" hat#hin - t(e first t(ree real val!es efine t(e s/acing of t(e (atc(lines. T(e fo!rt(val!e is not !se .

For $arametri# hat#hin - t(e first t%o real val!es efine t(e s/acing in u an v res/ectivel#. T(e last t%o val!es are not !se .

Planar *atch

-denti>ier	SD"5T9S'VP"'+'RV;'T-;		
Ty$eDid	8021		
)ntity ty$es	face		
!ie"ds	real	> com/onent	U irectionN or /lane normal
		# com/onent	
		H com/onent	
		U/itc(N or se/aration	
		> com/onent	/osition vector
		# com/onent	
		H com/onent	
Set 2y	'//lication		
7sed 2y	Parasoli (i en line an %ireframe images		

For /lanar (atc(ing) an attri0!te %it(t(is efinition ta3es /rece ence over an attri0!te %it(t(e SD"5T9S'V;'T-;&+6 efinition) if a face (as 0ot(t#/es of attri0!te attac(e .

Radial *atch

-denti>ier	SD"5T9S'VR'D&'"V;'T-;	
Ty$eDid	802C	
)ntity ty$es	face	
!ie"ds	real	ra ial aro!n
		ra ial along
		ra ial a0o!t
		ra ial aro!n start
		ra ial along start
		ra ial a0o!t start
Set 2y	'//lication	
7sed 2y	Parasoli (i en line an %ireframe images	

For ra ial (atc(ing) an attri0!te %it(t(is efinition ta3es /rece ence over an attri0!te %it(t(e SD"5T9S'V;'T-;&+6 efinition) if a face (as 0ot(t#/es of attri0!te attac(e .

Parametric *atch

-denti>ier	SD"5T9S'VP'R'$V;'T-;	
Ty$eDid	8028	
)ntity ty$es	face	
!ie"ds	real	! s/acing
		v s/acing
		! start
		v start
Set 2y	'//lication	
7sed 2y	Parasoli (i en line an %ireframe images	

For /arametric (atc(ing) an attri0!te %it(t(is efinition ta3es /rece ence over an attri0!te %it(t(e SD"5T9S'V;'T-;&+6 efinition) if a face (as 0ot(t#/es of attri0!te attac(e .

Density Attributes

T(ere are ensit# attri0!tes for eac(of regions) faces) e ges an vertices in a ition to t(e s#stem attri0!te for ensit# of a 0o #.

T(e region5face5e ge5verte> attri0!tes %

- Region +ensity

-denti>ier	SD"5T9S'VR.6&,+VD.+S&T9	
Ty$eDid	802B	
)ntity ty$es	region	
!ie"ds	real	Densit# of region
	string	4nits
Set 2y	'//lication	
7sed 2y	Parasoli $ass Pro/erties - calc!lation of mass	

T(is attri0!te onl# ma3es sense for soli regions? voi regions al%a#s (ave a mass of Hero.

' soli region %it(o!t a ensit# attri0!te is ta3en to (ave) 0# efa!lt) t(e same ensit# as its o%ning 0o #.

T(e c(aracter fiel !nits is not !se 0# Parasoli 0!t it can 0e set an rea 0# t(e !ser.

ace +ensity

-denti>ier	SD"5T9S'VF'-.VD.+S&T9	
Ty$eDid	802D	
)ntity ty$es	face	
!ie"ds	real	Densit# of face
	string	4nits
Set 2y	'//lication	
7sed 2y	Parasoli $ass Pro/erties - calc!lation of mass	

T(e val!e of t(is attri0!te is treate as a mass /er !nit area.

' mass %ill 0e calc!late for a face onl# %(en a face /ossesses t(is attri0!te. &n all ot(er cases t(e mass of a face is not efine .

T(e c(aracter fiel !nits is not !se 0# Parasoli 0!t it can 0e set an rea 0# t(e !ser.

- "dge +ensity

-denti>ier	SD"5T9S'V.D6.VD.+S&T9	
Ty$eDid	802E	
)ntity ty$es	e ge	
!ie"ds	real	Densit# of e ge
	string	4nits
Set 2y	'//lication	
7sed 2y	Parasoli $ass Pro/erties - calc!lation of mass	

T(e val!e of t(is attri0!te is treate as a mass /er !nit lengt(.

' mass %ill 0e calc!late for an e ge onl# %(en an e ge /ossesses t(is attri0!te. &n all ot(er cases t(e mass of an e ge is not efine .

T(e c(aracter fiel !nits is not !se 0# Parasoli 0!t it can 0e set an rea 0# t(e !ser.

#ertex +ensity

-denti>ier	SD"5T9S'VV.RT.8VD.+S&T9	
Ty$eDid	802F	
)ntity ty$es	verte>	
!ie"ds	real	$ass of verte>
	string	4nits
Set 2y	'//lication	
7sed 2y	Parasoli $ass Pro/erties - calc!lation of mass	

T(e val!e of t(is attri0!te is treate as a /oint mass.

' mass %ill 0e calc!late for a verte> onl# %(en a verte> /ossesses t(is attri0!te. &n all ot(er cases t(e mass of a verte> is not efine .

T(e c(aracter fiel !nits is not !se 0# Parasoli 0!t it can 0e set an rea 0# t(e !ser.

Region

-denti>ier	SD"5T9S'VR.6&,+	
Ty$eDid	801B	
)ntity ty$es	face	
!ie"ds	string	4n!se
Set 2y	'//lication	
7sed 2y	Parasoli (i en line images	

Regional ata %ill allo% t(e a//lication to anal#He a (i en-line /ict!re for istinct regions in t(e 2D vie%.

Colour

-denti>ier	SD"5T9S'V-,",4R		
ToEen	8001		
)ntity ty$es	face e ge		
!ie"ds	real	Re val!e	T(ese t(ree val!es s(o!l 0e in t(e range 0.0 to 1.0
		6reen val!e	
		:l!e val!e	
Set 2y	'//lication		
7sed 2y	'//lication		

Reflectivity

-denti>ier	SD"5T9S'VR.F".-T&V&T9	
ToEen	801D	
)ntity ty$es	face	
!ie"ds	real	-oefficient of s/ec!lar reflection
		Pro/ortion of colore lig(t in (ig(lig(ts
		-oefficient of iff!se reflection
		-oefficient of am0ient reflection
	integer	Reflection /o%er
Set 2y	'//lication	
7sed 2y	'//lication	

T(e attri0!te t#/es for Reflectivit# an Transl!cenc# are also !se 0# t(e Parasoli ro!tine RRP&8")0!t t(e !se of t(is ro!tine is not recommen e .

• Translucency

-denti>ier	SD"5T9S'VTR'+S"4-.+-9		
ToEen	801E		
)ntity ty$es	face		
!ie"ds	real	Trans/arenc# coefficient	range 0.0 to 1.0) %(ere 0 is o/aA!e an 1 is trans/arent
Set 2y	'//lication		
7sed 2y	'//lication		

Name

-denti>ier	SD"5T9S'V+'$.	
ToEen	801C	
)ntity ty$es	assem0l#) 0o #) instance) s(ell) face) loo/) e ge) verte>) gro!/) s!rface) c!rve) /oint	
!ie"ds	string	+ame of entit#
Set 2y	'//lication	
7sed 2y	'//lication	

.ntities rea into Parasoli from a Rom!l!s F.0 transmit file (ave t(eir names (el in name attri0!tes. ,nl# entities to %(ic(t(e !ser (as given names %ill 0e treate in t(is %a#.

Incremental faceting

-denti>ier	SD"5T9S'V&+-R.$.+T'"VF'-.TT&+6	
ToEen	T9S'&F	
)ntity ty$es	face	
!ie"ds	string	4n!se
Set 2y	Parasoli incremental face' '//lication	
7sed 2y	Parasoli incremental face' '//lication	

Transparency

-denti>ier	SD"5T9S'VTR'+SP'R.+-9	
ToEen	T9S'T9	
)ntity ty$es	:o #) face	
!ie"ds	integer	+on-Hero trans/arenc# coefficient val!e is trans/arent
Set 2y	'//lication	
7sed 2y	Parasoli (i en-li s	

'0o #ma#0e re ere trans/arent if it (as an attac(e trans/arenc# attri0!te %it(a -Hero trans/arenc# coefficient

Non-mergeable edges

-denti>ier	SD"5T9S'V+ J22S1OR m8.648663 0 Tdm(Vm0.9980727.1289 cm2.57175621 0 Tdm(6)T j m0.00159273	
ToEen	T9S'.+	
)ntity ty$es	e ge	
!ie"ds	string	4n!se
Set 2y	erasoli //mo eling n/erationsm ification	
7sed 2y	Parasoli mo eling o/erations	

&ri0!te of t(is oefinition at tac)it in icates t(at a ge t

&f an e ge (as an attri0!te of t(is efinition attac(e) it in icates t(at t(e e ge s(o!l not 0e merge in an# mo elling o/erations.T0 eTem[(e)-0.459646( )TJm0.00179a471 T cm15.1v42 0 Tdm(T)T j