REUSE MANUAL

ECKERT6

10xxxxxx.1

Implementation

TABLE OF CONTENTS

SECTION 1. INTRODUCTION

1.1 PURPOSE OF THE REUSE MANUAL

This document describes the characteristics of the ECKERT6 reusable software component and provides instructions on its installation and operation. The manual is a self-contained reference for the software engineer intending to incorporate the component in another software system. This manual was written with the assumption that the user has a basic working knowledge of C and is familiar with fundamental C concepts and terminology.

1.2 PURPOSE OF THE REUSABLE SOFTWARE COMPONENT

The purpose of ECKERT6 is to provide a reusable software component which supports the following coordinate conversions :

- Geodetic coordinates (latitude and longitude in radians) to Eckert VI projection coordinates (easting and northing in meters), and
- Eckert VI projection coordinates (easting and northing in meters) to Geodetic coordinates (latitude and longitude in radians).

A particular ellipsoid is specified in terms of the following parameters:

- Semi-Major Axis (a) – Radius (in meters) at the equator.
- Semi-Minor Axis (b) – Radius (in meters) at a pole.

A particular variation of the Eckert VI projection is specified in terms of the following parameters:

- Central Meridian – Longitude (in radians) at the horizontal center of the projection,
- False Easting – A coordinate value (in meters) assigned to the central meridian of the projection to avoid the inconvenience of using negative coordinates,
- False Northing – A coordinate value (in meters) assigned to the origin latitude of the projection to avoid the inconvenience of using negative coordinates.

1.3 GENERAL INFORMATION

1.3.1 POINT OF CONTACT

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1.3.2 CERTIFICATION LEVEL

This RSC has been certified at level 4. A level 4 component satisfies the criteria for reliability, testing, and documentation for the Army Reuse Center (ARC). The component comes with test materials and a Reuse Manual that aids in integrating the component into a software system.

1.3.3 LEGAL RESTRICTIONS

This Reusable Software Component (RSC) contains data with Unlimited Government Rights.

SECTION 2. INSTALLATION

The following is a list of the files that make up the ECKERT6 component:

Source Code Files:

```
eckert6.c
```

Header Files :

```
eckert6.h
```

Data Files :

```
none
```

The compilation instructions for the ECKERT VI component are as follows:

DOS Makefile (Uses Microsoft C):

```
cl /nologo /W3 /FR /G2 /DNDEBUG /Gs /Ox /AM /D_DOS /c eckert6.c
```

UNIX Makefile (Uses gcc compiler):

```
cc -g -O -ansi -Wall -c eckert6.c
```

The compilation order of the ECKERT6 component relative to other components is unconstrained.

2.1 PARTIAL REUSE

The ECKERT6 component does not allow for partial reuse.

2.2 MODIFICATIONS

The ECKERT6 component does not permit modifications.

SECTION 3. ENVIRONMENT

This section provides details on the environment under which ECKERT6 was developed, tested, and executed.

3.1 HARDWARE

3.1.1 DEVELOPMENT

The following is a list of hardware configurations under which ECKERT6 was developed and tested.

- SUN SparcStation 20
- IBM compatible Pentium PC

3.1.2 TARGET

The following is a list of hardware configurations under which ECKERT6 was executed.

- SUN SparcStation 20
- IBM compatible Pentium PC

3.2 SOFTWARE

3.2.1 OPERATING SYSTEM

The following is a list of operating systems under which ECKERT6 was executed and tested.

- Solaris 2.5
- Windows 95

3.2.2 COMPILERS

The following is a list of compilers on which ECKERT6 was compiled successfully.

- GCC version 2.8.1

- Microsoft Visual C++ version 6

3.3 ASSUMPTIONS AND PERFORMANCE LIMITATIONS

There are no hardware or environment constraints. There are no limitations.

This RSC is written in ANSI C.

SECTION 4. GLOBAL RSC ENVIRONMENT

4.1 TYPES

Not applicable.

4.2 CONSTANTS

The following is a list of significant visible constants declared globally in ECKERT VI with their descriptions.

```
ECK6_NO_ERROR                  : No errors occurred in function
ECK6_LAT_ERROR                 : Latitude outside of valid range
                                 (-90 to 90 degrees)
ECK6_LON_ERROR                 : Longitude outside of valid range
                                 (-180 to 360 degrees)
ECK6_EASTING_ERROR             : Easting outside of valid range
                                 (False_Easting +/- ~18,000,000 m,
                                 depending on ellipsoid parameters)
ECK6_NORTHING_ERROR            : Northing outside of valid range
                                 (False_Northing +/- 0 to ~8,000,000 m,
                                 depending on ellipsoid parameters)
ECK6_ORIGIN_LAT_ERROR          : Origin latitude outside of valid range
                                 (-90 to 90 degrees)
ECK6_CENT_MER_ERROR            : Central meridian outside of valid range
                                 (-180 to 360 degrees)
ECK6_A_ERROR                   : Semi-major axis less than or equal to zero
ECK6_B_ERROR                   : Semi-minor axis less than or equal to zero
ECK6_A_LESS_B_ERROR            : Semi-major axis less than semi-minor axis
```

4.3 VARIABLES

The following is a list of significant global variables declared in ECKERT6 with their descriptions.

```
Ellipsoid Parameters:
static double Eck6_a             : Semi-major axis of ellipsoid in meters
static double Eck6_b             : Semi-minor axis of ellipsoid in meters

Projection Parameters:
static double Eck6_Origin_Lat    : Latitude of origin in radians
static double Eck6_Origin_Long   : Longitude of origin in radians
static double Eck6_False_Easting : False easting in meters
static double Eck6_False_Northing   : False northing in meters

Maximum easting and northing values (for default ellipsoid and projection):
static double Eck6_Delta_Easting
static double Eck6_Delta_Northing
```

4.4 INCLUDE FILES

```
math.h                          : Standard C math library
eckert6.h                       : Error codes and prototype error checking
```

4.5 DEPENDENCIES

None, other than the standard ANSI C math library.

SECTION 5. FUNCTIONS

5.1 SET_ECKERT6_PARAMETERS

5.1.1 DESCRIPTION

This function sets the ellipsoid and Eckert VI projection parameters to the specified values.

5.1.2 INTERFACES AND EXAMPLES

The following is a list of the formal arguments required to use this function.

```
long Set_Eckert6_Parameters (double a,
             double b,
             double Central_Meridian,
             double False_Easting,
             double False_Northing);
```

a	Semi-major axis of ellipsoid in meters (input),
b	Semi-minor axis of ellipsoid in meters (input),
Central_Meridian	Longitude in radians at the center of the projection (input),
False_Easting	Coordinate value in meters assigned to the central meridian (input),
False_Northing	Coordinate value in meters assigned to the origin latitude (input),

Example:

```
status = Set_Eckert6_Parameters (a, b, Origin_Latitude, Central_Meridian,
            False_Easting, False_Northing)
```

Inputs:

a	6371007.0 (Radius of sphere with same surface area as WGS84 Ellipsoid)
b	6371007.0 (Radius of sphere with same surface area as WGS84 Ellipsoid)
Origin_Latitude	0.0
Central_Meridian	0.0

False_Easting 0.0

False_Northing 0.0

Outputs:

None

5.1.3 DECLARATIONS

5.1.3.1 TYPES

Not applicable.

5.1.3.2 CONSTANTS

Not applicable.

5.1.3.3 VARIABLES

Not applicable.

5.1.4 DEPENDENCIES

Convert_Eckert6_To_Geodetic – used to determine maximum valid easting and northing values for current ellipsoid and Eckert6 projection parameters.

5.1.5 ERROR HANDLING

This function returns the following status codes:

```
ECK6_NO_ERROR                   : No errors occurred in function
ECK6_ORIGIN_LAT_ERROR           : Origin latitude outside of valid range
                                  (-90 to 90 degrees)
ECK6_CENT_MER_ERROR             : Central meridian outside of valid range
                                  (-180 to 360 degrees)
ECK6_A_ERROR                    : Semi-major axis less than or equal to zero
ECK6_B_ERROR                    : Semi-minor axis less than or equal to zero
ECK6_A_LESS_B_ERROR             : Semi-major axis less than semi-minor axis
```

5.2 GET_ECKERT6_PARAMETERS

5.2.1 DESCRIPTION

This function returns the current values of the ellipsoid parameters, and Eckert VI projection parameters.

5.2.2 INTERFACES AND EXAMPLES

The following is a list of the formal arguments required to use this function.

```
void Get_Eckert6_Parameters (double *a,
             double *b,
             double *Central_Meridian,
             double *False_Easting,
             double *False_Northing);
```

a	Semi-major axis of ellipsoid in meters (output),
b	Semi-minor axis of ellipsoid in meters (output),
Central_Meridian	Longitude in radians at the center of the projection (output),
False_Easting	Coordinate value in meters assigned to the central meridian (output),
False_Northing	Coordinate value in meters assigned to the origin latitude (output),

5.2.3 DECLARATIONS

5.2.3.1 TYPES

Not applicable.

5.2.3.2 CONSTANTS

Not applicable.

5.2.3.3 VARIABLES

Not applicable.

5.2.4 DEPENDENCIES

None.

5.2.5 ERROR HANDLING

No errors are reported by this function.

5.3 CONVERT_GEODETIC_TO_ECKERT6

5.3.1 DESCRIPTION

This function converts Geodetic coordinates (latitude and longitude in radians) to Eckert VI projection coordinates (easting and northing in meters), using the current ellipsoid and Eckert VI projection parameters.

5.3.2 INTERFACES AND EXAMPLES

The following is a list of the formal arguments required to use this function.

```
long Convert_Geodetic_To_Eckert6 (double Latitude,
             double Longitude,
             double *Easting,
             double *Northing);
```

Latitude	Latitude in radians (input),
Longitude	Longitude in radians (input),
Easting	Easting (X) in meters (output),
Northing	Northing (Y) in meters (output).

Example:

```
status = Convert_Geodetic_To_Eckert6 (Latitude, Longitude, Easting, Northing)
```

Inputs:

Latitude:	-35.0
Longitude:	75.0

Outputs:

Easting:	-1765593.68
Northing:	-4354477.83

5.3.3 DECLARATIONS

5.3.3.1 TYPES

Not applicable.

5.3.3.2 CONSTANTS

Not applicable.

5.3.3.3 VARIABLES

Not applicable.

5.3.4 DEPENDENCIES

None.

5.3.5 ERROR HANDLING

This function returns the following status codes:

```
ECK6_NO_ERROR                   : No errors occurred in function
ECK6_LAT_ERROR                  : Latitude outside of valid range
                                  (-90 to 90 degrees)
ECK6_LON_ERROR                  : Longitude outside of valid range
                                  (-180 to 360 degrees)
```

5.4 CONVERT_ECKERT6_TO_GEODETIC

5.4.1 DESCRIPTION

This function converts Eckert VI projection coordinates (easting and northing in meters) to Geodetic coordinates (latitude and longitude in radians), using the current ellipsoid and Eckert VI projection parameters.

5.4.2 INTERFACES AND EXAMPLES

The following is a list of the formal arguments required to use this function.

```
long Convert_Eckert6_To_Geodetic (double Easting,
             double Northing,
             double *Latitude,
             double *Longitude);
```

Easting	Easting (X) in meters (input),
Northing	Northing (Y) in meters (input),
Latitude	Latitude in radians (output),
Longitude	Longitude in radians (output).

Example:

```
status = Convert_Eckert6_To_Geodetic (Easting, Northing, Latitude, Longitude)
```

Inputs:

Easting:	-1765593.68
Northing:	-4354477.83

Outputs:

Latitude:	-35.0
Longitude:	75.0

5.4.3 DECLARATIONS

5.4.3.1 TYPES

Not applicable.

5.4.3.2 CONSTANTS

Not applicable.

5.4.3.3 VARIABLES

Not applicable.

5.4.4 DEPENDENCIES

None.

5.4.5 ERROR HANDLING

This function returns the following status codes:

```
ECK6_NO_ERROR                   : No errors occurred in function
ECK6_EASTING_ERROR              : Easting outside of valid range
                                  (False_Easting +/- ~18,000,000 m,
                                  depending on ellipsoid parameters)
ECK6_NORTHING_ERROR             : Northing outside of valid range
                                  (False_Northing +/- 0 to ~8,000,000 m,
                                  depending on ellipsoid parameters)
```

APPENDIX A STRUCTURE/DEPENDENCY DIAGRAMS

This component consists of a single compilation unit and depends only on the ANSI C standard math library.

APPENDIX B DEFINITIONS/GLOSSARY

Central Meridian – Longitude at the horizontal center of a projection; Origin Longitude.

Coordinate – Linear or angular quantities that designate the position that a point occupies in a given reference frame or system. Also used as a general term to designate the particular kind of reference frame or system, such as Cartesian or spherical coordinates.

Eckert VI Projection – A pseudocylindrical, equal-area projection for which the scale factor is one along latitudes $49^{o}16'$ N and S. The central meridian is a straight line, and all other meridians are sinusoidal curves. The implementation of this projection within GEOTRANS uses a spherical Earth model.

Ellipsoid – The surface generated by an ellipse rotating about one of its axes.

False Easting – A coordinate value (in meters) assigned to the central meridian of the projection to avoid the inconvenience of using negative coordinates.

False Northing – A coordinate value (in meters) assigned to the origin latitude of the projection to avoid the inconvenience of using negative coordinates.

Geodetic Coordinates – The quantities of latitude and longitude that define the position of a point on the surface of the earth with respect to the reference ellipsoid. Also, imprecisely called geographic coordinates.

Geodetic Latitude – The angle between the plane of the equator and the normal to the ellipsoid through the computation point. Geodetic latitude is positive north of the equator and negative south of the equator.

Geodetic Longitude – The angle between the plane of a meridian and the plane of the prime meridian. A longitude can be measured from the angle formed between the local and prime meridians at the pole of rotation of the reference ellipsoid, or by the arc along the equator intercepted by these meridians.

Map Projection – A function relating coordinates of points on a curved surface (usually an ellipsoid or sphere) to coordinates of points on a plane. A map projection may be established by analytical computation or, less commonly, may be constructed geometrically.

Map Scale – The ratio between a distance on a map and the corresponding actual distance on the earth's surface.

Meridian – A north-south reference line, particularly a great circle through the geographical poles of the earth, from which longitudes and azimuths are determined; or the

intersection of a plane forming a great circle that contains both geographic poles of the earth, and the ellipsoid.

Origin Latitude – Latitude at which the scale factor of the projection is 1.0.

Parallel – A line on the earth, or a representation thereof, that represents the same latitude at every point.

Scale Factor (Projection) – A multiplier for reducing a distance in a map projection to the actual distance on the chosen reference ellipsoid.

APPENDIX C REFERENCES

(1) Topographic Engineering Center, TEC-SR-7,.**Handbook for transformation of DATUMS, PROJECTIONS, GRIDS, AND COMMON COORDINATE SYSTEMS**, January 1996.

(2) Snyder, J. P., **Geological Survey Professional Paper 1395 Map Projections - A Working Manual**, 1987.