REUSE MANUAL

UTM

10xxxxxx.1

Implementation

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SECTION 1. INTRODUCTION

1.1 PURPOSE OF THE REUSE MANUAL

This document describes the characteristics of the UTM 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 UTM is to provide a reusable software component which supports the following coordinate conversions :

- Geodetic coordinates (latitude and longitude in radians) to Universal Transverse Mercator (UTM) projection coordinates (zone, hemisphere, easting in meters, and northing in meters), with an option to specify the zone,

- Universal Transverse Mercator (UTM) projection coordinates (zone, hemisphere, easting in meters, 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, and

- Semi-Minor Axis (b): Radius (in meters) at a pole.

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 compilation files for the UTM component:

Source Code Files:

```
utm.c
```

Header Files :

```
utm.h
```

Data Files :

```
none
```

The compilation instructions for the UTM component are as follows:

DOS Makefile (Uses Microsoft C):

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

UNIX Makefile (Uses gcc compiler):

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

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

2.1 PARTIAL REUSE

The UTM component does not allow for partial reuse.

2.2 MODIFICATIONS

The UTM component does not permit modifications.

SECTION 3. ENVIRONMENT

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

3.1 HARDWARE

3.1.1 DEVELOPMENT

The following is a list of hardware configurations under which UTM 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 UTM 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 UTM was executed and tested.

- Solaris 2.5
- MS-DOS version 6.22

3.2.2 COMPILERS

The following is a list of compilers on which UTM 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 UTM with their descriptions.

```
UTM_NO_ERROR                    : No errors occurred in function
UTM_LAT_ERROR                   : Latitude outside of valid range
                                  (-80.5 to 84.5 degrees)
UTM_LON_ERROR                   : Longitude outside of valid range
                                  (-180 to 360 degrees)
UTM_EASTING_ERROR               : Easting outside of valid range
                                  (100,000 to 900,000m)
UTM_NORTHING_ERROR              : Northing outside of valid range
                                  (0 to 10,000,000m)
UTM_ZONE_ERROR                  : Zone outside of valid range
                                  (1 to 60)
UTM_HEMISPHERE_ERROR            : Invalid hemisphere ('N' or 'S')
UTM_ZONE_OVERRIDE_ERROR         : Zone outside of valid range
                                  (1 to 60, within 1 of 'natural' zone)
UTM_A_ERROR                     : Semi-major axis less than or equal to zero
UTM_B_ERROR                     : Semi-minor axis less than or equal to zero
UTM_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 UTM with their descriptions.

```
Ellipsoid Parameters:
static double UTM_a             : Semi-major axis of ellipsoid in meters
static double UTM_b             : Semi-minor axis of ellipsoid in meters

Zone Override:
static long UTM_Zone_Override   : Override zone
```

4.4 INCLUDE FILES

```
tranmerc.h                      : UTM depends on Transverse Mercator
utm.h                           : Used for prototype checking
```

4.5 DEPENDENCIES

The following is a list of the software external to the RSC and its descriptions.

TRANSVERSE MERCATOR, since the Universal Transverse Mercator projection in each zone is a special case of the Transverse Mercator projection.

SECTION 5. FUNCTIONS

5.1 SET_UTM_PARAMETERS

5.1.1 DESCRIPTION

This function sets the ellipsoid parameters, and optional zone override parameter, 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_UTM_Parameters (double a,
             double b,
             long   Override_Zone)
```

a	Semi-major axis of ellipsoid in meters (input),
b	Semi-minor axis of ellipsoid in meters (input),
Override_Zone	UTM zone to be used in subsequent coordinate conversions, zero indicates no override specified (input).

Example:

```
status = Set_UTM_Parameters (a, b, Override_Zone)
```

Inputs:

a	6378137.0	
b	6356752.3142	
Override_Zone	0	(no override specified)

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

None.

5.1.5 ERROR HANDLING

This function returns the following status codes:

```
UTM_NO_ERROR                    : No errors occurred in function
UTM_ZONE_OVERRIDE_ERROR         : Zone outside of valid range
                                    (1 to 60, within 1 of 'natural' zone)
UTM_A_ERROR                     : Semi-major axis less than or equal to zero
UTM_B_ERROR                     : Semi-minor axis less than or equal to zero
UTM_A_LESS_B_ERROR              : Semi-major axis less than semi-minor axis
```

5.2 GET_UTM_PARAMETERS

5.2.1 DESCRIPTION

This function returns the current values of the ellipsoid parameters, and optional zone override parameter.

5.2.2 INTERFACES AND EXAMPLES

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

```
void Get_UTM_Parameters (double *a,
             double *b,
```

```
        long   *Override)
```

a	Semi-major axis of ellipsoid in meters (output),
b	Semi-minor axis of ellipsoid in meters (output),
Override	UTM zone to be used in subsequent coordinate conversions, zero indicates no override specified (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_UTM

5.3.1 DESCRIPTION

This function converts Geodetic coordinates (latitude and longitude in radians) to Universal Transverse Mercator (UTM) projection coordinates (zone, hemisphere, easting in meters, and northing in meters), using the current ellipsoid parameters, and the optional zone override parameter.

5.3.2 INTERFACES AND EXAMPLES

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

```
long Convert_Geodetic_To_UTM (double Latitude,
             double Longitude,
             long   *Zone,
             char   *Hemisphere,
             double *Easting,
             double *Northing)
```

Latitude	Latitude in radians (input),
Longitude	Longitude in radians (input),
Zone	UTM zone (1 to 60) (output),
Hemisphere	Northern (‘N’) or Southern (‘S’) hemisphere (output),
Easting	Easting (X) in meters (output),
Northing	Northing (Y) in meters (output).

Example:

```
status = Convert_Geodetic_To_UTM (Latitude, Longitude, Zone, Hemisphere,
            Easting, Northing)
```

Inputs:

Latitude:	35.0
Longitude:	-75.0

Outputs:

Zone:	18
Hemisphere:	‘N’
Easting:	500000
Northing:	3873042

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

Set_Transverse_Mercator_Parameters, in the TRANSVERSE MERCATOR component – used to set the parameters of the Mercator projection, and

Convert_Geodetic_To_Transverse_Mercator, in the TRANSVERSE MERCATOR component – used to convert geodetic (latitude and longitude) coordinates to Transverse Mercator (easting and northing) projection coordinates.

5.3.5 ERROR HANDLING

This function returns the following status codes:

```
UTM_NO_ERROR                : No errors occurred in function
UTM_LAT_ERROR               : Latitude outside of valid range
                              (-80.5 to 84.5 degrees)
UTM_LON_ERROR               : Longitude outside of valid range
                              (-180 to 360 degrees)
UTM_EASTING_ERROR           : Easting outside of valid range
                              (100,000 to 900,000m)
UTM_NORTHING_ERROR          : Northing outside of valid range
                              (0 to 10,000,000m)
UTM_ZONE_OVERRIDE_ERROR     : Zone outside of valid range
                              (1 to 60, within 1 of 'natural' zone)
```

5.4 CONVERT_UTM_TO_GEODETIC

5.4.1 DESCRIPTION

This function converts Universal Transverse Mercator (UTM) projection coordinates (zone, hemisphere, easting in meters, and northing in meters) to Geodetic coordinates (latitude and longitude in radians), using the current ellipsoid parameters.

5.4.2 INTERFACES AND EXAMPLES

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

```
long Convert_UTM_To_Geodetic (long Zone,
             char   Hemisphere,
             double Easting,
             double Northing,
             double *Latitude,
             double *Longitude)
```

Zone	UTM zone (1 to 60) (input),
Hemisphere	Northern (‘N’) or Southern (‘S’) hemisphere (input),
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_UTM_To_Geodetic (Zone, Hemisphere, Easting, Northing,
            Latitude, Longitude)
```

Inputs:

Zone:	18
Hemisphere:	‘N’
Easting:	500000
Northing:	3873042

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

Set_Transverse_Mercator_Parameters, in the TRANSVERSE MERCATOR component – used to set the parameters of the Mercator projection, and

Convert_Transverse_Mercator_To_Geodetic, in the TRANSVERSE MERCATOR component – used to convert Transverse Mercator (easting and northing) projection coordinates to geodetic (latitude and longitude) coordinates.

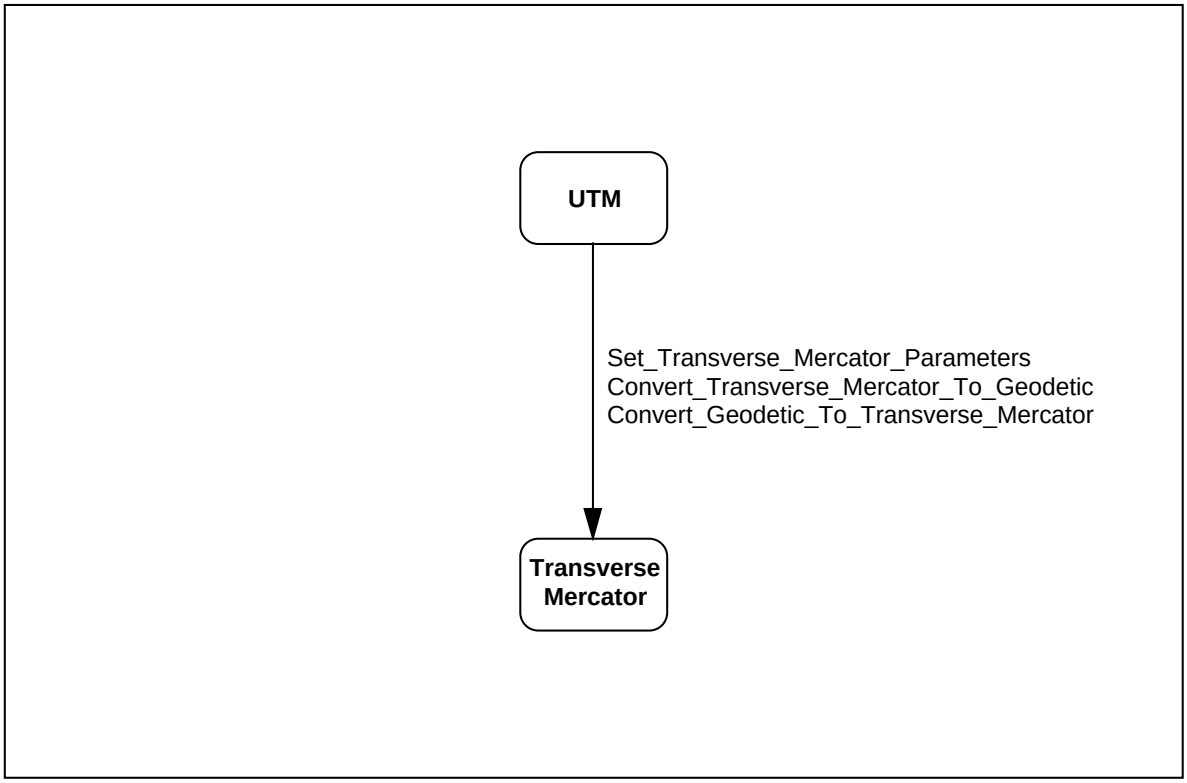
5.4.5 ERROR HANDLING

This function returns the following status codes:

```
UTM_NO_ERROR                : No errors occurred in function
UTM_LAT_ERROR               : Latitude outside of valid range
                              (-80.5 to 84.5 degrees)
UTM_EASTING_ERROR           : Easting outside of valid range
                              (100,000 to 900,000m)
UTM_NORTHING_ERROR          : Northing outside of valid range
                              (0 to 10,000,000m)
UTM_ZONE_ERROR              : Zone outside of valid range
                              (1 to 60)
UTM_HEMISPHERE_ERROR        : Invalid hemisphere (‘N’ or ‘S’)
```

APPENDIX A STRUCTURE/DEPENDENCY DIAGRAMS

This component consists of a single compilation unit and depends on the TRANSVERSE MERCATOR component.



APPENDIX B DEFINITIONS/GLOSSARY

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.

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

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.

Meridian – A north-south reference line, particularly a great circle through the geo–graphical 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.

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

Transverse Mercator Projection – A conformal projection for which the scale factor is one along the central meridian. The line Y = 0 is the projection of the equator, and the line X=0 is the projection of the central meridian.

Universal Transverse Mercator (UTM) Projection – A family of projections based on the Transverse Mercator projection, in which the ellipsoid is divided into 60 longitudinal zones fo 6 degress each. The X value, called the easting, has a value of 500,000m at the central meridian of each zone. The Y value, called the northing, has a value of 0m at the equator for the northern hemisphere, increasing toward the north pole, and a value of 10,000,000m at the equator for the southern hemisphere, decreasing toward the south pole. The point scale factor along the central meridian is 0.9996.

APPENDIX C REFERENCES

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