Unmanned Aircraft Systems (UAS) Traffic Management (UTM)

Technical Capability Level 2.0

Software Version Description

Version 1.0

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TCL 2.0 Software Version Description

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Version History

Version	Date	Sections Affected	Description of Change	Author
1.0	2016-02-27	N/A	Initial Version	Patrick McGuirk

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1   INTRODUCTION

1.1   Identification

This is the Unmanned Aircraft Systems (UAS) Traffic Management (UTM) Technical Capability Level (TCL) 2.0 Software Version Description (SVD) document.

1.2   System Overview

UTM will enable safe and efficient UAS operations in low-altitude uncontrolled airspace (Figure 1.1) by providing services such as airspace design, flight planning, flight monitoring, hazardous weather and wind avoidance, terrain and vertical obstruction warnings, separation assurance, congestion management, and contingency planning. It leverages, both conceptually and architecturally, the lessons learned from the well-established air traffic management (ATM) system, and the future plans of the Federal Aviation Administration's (FAA's) Next Generation Air Transportation System (NextGen). It also applies emerging capabilities of autonomous vehicles.

Figure 1.1 – UTM Overview

The UTM TCL 1.0 release enabled safe UAS operations in specific geographic areas. The UTM TCL 1.0 capabilities were defined by two key criteria: visual line-of-sight (VLOS) operations over unpopulated land or water and no manned aviation traffic in the area. Even given these restrictions, TCL 1.0 enabled many use cases, including infrastructure monitoring and inspections, mapping, science applications, firefighting and videography/photography, among others.

The UTM TCL 2.0 release extends the capabilities of TCL 1.0 to include beyond visual line-of-sight (BVLOS) operations, also known as "expanded operations," over sparsely populated areas. The introduction of external surveillance system operations allows UAS operations within general

proximity of manned aircraft, although UAS operations and manned aircraft are still expected to remain well separated.

Additionally, TCL 2.0 enables more efficient use of the airspace by supporting segmented operations as well as altitude-stratified operations. In a segmented operation plan, rather than reserve an entire operational region, a UAS operator reserves one section of airspace at a time, releasing the previous segment as the UAS enters the next segment. In altitude-stratified operations, two or more UAS may operate over the same area while remaining safely separated vertically. TCL 2.0 also introduces contingency management procedures for cases where UAS operators cannot or do not fly their operations as filed.

The TCL 2.0 release consists of two components: the UTM Core and a UTM client reference implementation. The UTM Core comprises the UTM server while the client reference implementation is provided as a tool to exercise the UTM Core, though UTM users are encouraged to develop their own UTM client. The UTM Core defines a uniform interface for sending information to and receiving data from UAS operators, as specified in the UTM Client Interface Control Document (ICD).

1.3   Document Overview

This UTM TCL 2.0 SVD describes the following four topics:

1. Software Release Contents
    a. A listing of the files comprising this release
2. Installation Instructions
    a. How to install the release and get it running
3. Changes Since Previous Release
    a. General updates since the previous UTM release
4. Known Issues
    a. Known issues and limitations in this release

2   REFERENCE DOCUMENTS

Document Number	Document Title
NPR 7150.2B	NASA Software Engineering Requirements
NASA-STD-8739.8	NASA Software Assurance Standard

3 VERSION DESCRIPTION

3.1 Software Release Contents
The UTM TCL 2.0 release includes the files listed in Table 3.1 below.

Table 3.1 – UTM TCL 2.0 Release Contents

No.	File Name	Description	Size
1	utmC7.TCL2.ova	UTM TCL 2.0 VirtualBox Virtual Machine (VM)	5.9 GB
2	UTM-TCL2-170227-SVD-v1.0.pdf	UTM TCL 2.0 Software Version Description Document	215 KB

Table 3.2 describes the version information of the components included in or associated with UTM TCL 2.0. Note that the UTM Client ICD is released separately.

Table 3.2 – UTM TCL 2.0 Version Information

Component	Version
UTM Core Software	2.0
UTM Application Programming Interface (API) Definition	1
UTM Client ICD	2.2
UTM Common Surveillance ICD	0.3
UTM TCL 2.0 Software Version Description Document	1.0

3.2 Installation Instructions
This section includes basic instructions for how to install and run the UTM Core. The TCL 2.0 UTM Core release is included in an OVA-packaged virtual machine (VM). (Future UTM releases may or may not be released in this virtual machine format.) This OVA package is an open virtualization-formatted file which may be imported into popular tools such as VirtualBox or VMware. These installation instructions are based on VirtualBox, though usage of VMware should be similar.

3.2.1 Required Components
The following components are required to install the TCL 2.0 UTM Core:
- VirtualBox (https://www.virtualbox.org)
  - Note that VMware may also be used, though as mentioned above, these instructions refer to VirtualBox.
- TCL 2.0 UTM Core VirtualBox VM: `utmC7.TCL2.ova`
- At least 40 GB of free hard drive space
- At least 4 GB of RAM

3.2.2 VM Information
The TCL 2.0 UTM Core VirtualBox VM is configured as follows:

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- **VM Name:** utmC7.TCL2
- **Operating System:** CentOS Linux 7.3.1611
- **CPU Configuration:** One CPU
- **RAM:** 4 GB RAM
- **Hard Drive Storage:** 40 GB storage (dynamic)
- **Network Adapter:** Intel PRO/1000 MT Desktop

The login information for the basic UTM Linux user is as follows:

- **User Name:**   `tmiuser`
- **Password:**   `utm2015!`

The user `tmiuser` is a member of the `wheel` Linux group and has root privileges using the `sudo` command. All files relating to UTM can be found in the `tmiuser` home directory: `/home/tmiuser/`.

3.2.3   Importing the VM

1. From VirtualBox, import the `utmC7.TCL2.ova` file:
   a. Start VirtualBox.
   b. From the Oracle VM VirtualBox Manager window, select 'Import Appliance...' from the VirtualBox File menu, browse to the file then click Continue.
   c. In the Appliance settings window, perform the following steps:
      i. Verify the following settings and update them, if necessary:
         1. CPU   1
         2. RAM   4096 MB
         3. Network Adapter   Intel PRO/1000 MT Desktop
      ii. Check the 'Reinitialize the MAC address of all network cards' checkbox.
      iii. Click the Import button.
   d. It will take a minute or two to import the OVA appliance.

2. To start using the VM, simply select "utmC7.TCL2" from the VM listing and click the 'Start' toolbar button at the top of the VirtualBox window. A VM window will open which will simulate a CentOS 7.3 system.

3. Wait roughly 20 seconds or so for the VM to boot and a user login window should appear.

4. Log in using the user credentials provided in the previous section.

5. Once loaded, you may refer to the README file inside the VM in '/home/tmiuser/README.txt.' This file repeats the instructions in this software version description regarding how to start and run the UTM Core inside the VM.

Optional
6. Once the VM has been initialized with the steps specified in the following instructions, the UTM service is accessible through `http://127.0.0.1:8090` on the host machine.

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3.2.4   Notes on Networking

To access the VM inside a closed network from a different machine, the simplest way would be to set up some sort of port forwarding on the host machine that passes port 80 to 8090. To forward a port, one can use examples such as Apache HTTP Server (httpd) or NGINX.

The main purpose of this VM is to demonstrate the features and functionalities of the UTM Core. It is strongly recommended that this TCL 2.0 version of the UTM Core be used within the environment inside this VM. It should not be used as a fully functional standalone UTM Core.

To run the UTM Core as a standalone service on a web server that has been vetted by a system administrator, the following components with respective versions are required.

- Java 1.8+
- PostgreSQL 9.4+
- PostGIS 2.1+
- ApacheDS 2.0.0-M20+
- Apache ActiveMQ 5.13+
- Apache Tomcat 8+

The UTM components can be found inside the VM in the `/home/tmiuser` directory.

3.2.5   Starting UTM Core

To start the UTM Core software, run the UTM startup script using `sudo` (see below). This script will start all services required by the UTM Core.

```
sudo /home/tmiuser/start_utm.sh
```

The following components will be started:

- Apache ActiveMQ 5.13.0
- ApacheDS 2.0.0_M20
- Apache Tomcat 8.0.37
- PostgreSQL 9.4.5

3.2.6   PostgreSQL 9.4 User Account

The PostgreSQL 9.4 user account credentials are as follows:

- **User Name:**   `tmiuser`
- **Password:**   `tmiuser`

3.2.7   Generate ssh Keys

If this is the first time running this VM, run the `systemctl` command shown below. The purpose of this command is to regenerate `ssh` keys for this VM image.

```
sudo systemctl restart sshd
```

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3.2.8   UTM LDAP User Accounts

The UTM Core software installed in this VM includes the UTM user accounts shown below. Note that these are not Linux user accounts in the VM, but rather Lightweight Directory Access Protocol (LDAP) accounts known to the UTM Core.

UTM standard user accounts
The following accounts have standard UTM user permissions. These accounts are used to emulate nominal UTM users.

User Name: vmUser
Password: vmuser

User Name: guest
Password: guest

User Name: guest1
Password: guest1

User Name: guest2
Password: guest2

User Name: guest3
Password: guest3

UTM high-priority account
The following account emulates a public safety user (e.g., law enforcement, fire services, emergency medical services). Operation plans submitted by a high-priority account will supersede operation plans submitted by standard users.

User Name: utmEmergency
Password: utmemergency

UTM surveillance user account
The following account emulates an external surveillance service provider (e.g., radar services).

User Name: surOpsUser
Password: suropsuser

UTM Manager account
The following account is for the UTM Manager role.

User Name: utmMgr
Password: utmmgr

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3.2.9   Creating a new LDIF File (if desired)

This section describes how to create a new user LDAP Data Interchange Format (LDIF) file. Note that an LDIF file for the 'vmUser' and 'utmEmergency' LDAP accounts already exists, as described below.

There are sample LDIF files located in the following directory:

```
/home/tmiuser/add_new_user/
```

Inside this directory you will find two LDIF files:

new_user_template.ldif: This file contains the base for adding a new user account.

utm_users.ldif: This file contains the information that was used to add the
                              vmUser and utmEmergency accounts.

To create a new LDIF file, simply copy 'new_user_template.ldif' and modify its contents, as follows (the lines that needs to be modified for the following sections are enclosed by 'xx'):

1. Creating the user:

```
dn:            uid=xxtheUserNamexx,ou=People,dc=nasa,dc=gov
cd:            xxCommonNamexx
sn:            xxSurNamexx
description:   xxDescription of the user or organizationxx
givenname:     xxFirst or given namexx
userPassword:  xxPasswordxx
```

2. If the user to be created is intended to be a UTM Manager, the lines that contains 'CLIENT' will need to be modified and changed to 'MGR.'

```
        dn:   cn=CLIENT,ou=Groups,dc=nasa,dc=gov
        cn:   CLIENT
```

3. Adding the user to group/role

```
uniquemember:  uid=xxtheUserNamexx,ou=People,dc=nasa,dc=gov
```

More details are included in the example LDIF file.

3.2.10   Adding a New UTM LDAP User (if desired)

This section describes how to add a new LDAP user. This assumes an LDIF file for the new user has been created, as described above. As mentioned previously, several UTM LDAP accounts already exist.

To add a new LDAP user, perform the following steps:

1. Make sure the start_utm.sh script has been executed.

2. Verify ApacheDS is up and running. (This service is started when running `start_utm.sh`.)

        sudo /etc/init.d/apacheds-2.0.0_M20-default status

   This command should return the following:

        ApacheDS - default is running (<Process ID>)

3. Start Apache Directory Studio.

        /home/tmiuser/ApacheDirectoryStudio/ApacheDirectoryStudio &

4. In the Connection section of Apache Directory Studio (located in the lower left pane of the window), double-click on the connection labeled '`local`.' Highlighting the connection then clicking on the Open Connection toolbar button works as well.

   An Open Connection window will pop up as the connection is established.

    NOTE: If the ApacheDS service was just started, it might take a few minutes to be fully up and running. Try again if the first few attempts fail.

5. Once the connection has been established, go to the 'LDAP Browser' section of Apache Directory Studio (located in the upper left pane of the window) and right-click on the '`dc=nasa,dc=gov`' entry to bring up its context menu. In the context menu, select 'LDIF Import...' from the 'Import' menu. The LDIF Import window will launch.

6. In the 'LDIF Import' window, go to the 'LDIF File' field and browse to your newly created LDIF file and click the OK button. Before clicking on the Finish button, select 'Overwrite existing logfile' in the Logging section of the LDIF Import window.

7. Click 'Finish' to complete the import. (Note that an error may be generated if an import is attempted multiple times for the same user name and password.)

8. If there were no issues in the new LDIF file, the new user will be added to LDAP.

3.2.11 Registering a New User in the UTM Core (if desired)
This section describes registering the new user in the UTM Core. Note that the existing users are already registered.

To complete adding a newly created user in UTM, the username will need to be added to the database. To add a user to the database, a Structured Query Language (SQL) script will need to be executed using '`pgadmin`' or '`psql`,' though the details of running these commands are not described here.

There is a sample script in the following location:

        /home/tmiuser/add_new_user/new_user_template.sql

As an example, there is also a SQL script that was used to add `vmUser`:

```
/home/tmiuser/add_new_user/add_user_vmuser.sql
```

The SQL script will add an entry to the user table and the operator table (if there is a new operator).

3.2.12   Using the UTM Core

The TCL 2.0 release includes some additional information and components to help get started with UTM. This includes a description of the UTM API and two UTM client implementations (a Python client and a web client), as described below. However, this document does not include detailed instructions regarding how to use the UTM Core software or how to create a UTM client.

3.2.12.1   UTM RESTful API Description

The UTM RESTful API description is available inside the VM. It lists all available URL endpoints that TCL 2.0 of the UTM Core supports and how to use them. To access this description, open Firefox and browse to the following URL:

```
http://127.0.0.1/tcl2/utm/api/
```

Note: This assumes that the Apache server has been started as described in Section 3.2.5.

3.2.12.2   UTM Python Client

A reference UTM client has been implemented in Python and can be launched using the following command:

```
python /home/tmiuser/client/utm_tcl2_v5.py &
```

This client can be used to submit a plan to the UTM Core. Note that an example waypoint file is also available at the following location:

```
/home/tmiuser/client/fp4.txt
```

3.2.12.3   UTM Web Client

A reference web client is also available and can be used to both submit operation plans to the UTM Core as well as view plans. This client can be launched by opening Firefox inside the VM and browsing to the following URL:

```
http://127.0.0.1/tcl2/utm/
```

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3.4   Changes Since Previous Release

The following table describes the major changes and updates in this release.

<div align="center">

Table 3.3 – Changes Since the Previous Release

</div>

No.	Feature
1	Multisegmented UAS operation plans are now supported.
2	Operation plan segments may be defined as volumes and/or LineStrings.
3	Altitude-stratified operations are supported.
4	External surveillance systems (e.g., radar, ADS-B) are supported through external surveillance operation plans.
5	Contingency management procedures are supported for UAS operators who either want to modify an active operation plan or are unable to continue with the operation plan as filed.

3.5   Known Issues

The following table lists known issues and limitations in this release.

<div align="center">

Table 3.4 – Known Issues

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No.	Issue
1	The UTM Core does not accept external data sources (e.g., NOTAMs, TFRs, weather services).
2	The UTM Core does not identify airspace regions closed due to weather conditions.
3	Terrain, natural obstacle and man-made structure data are available.
4	The UTM Core does not handle interactions between multiple UTM Core instances.
5	The UTM Core supports only one airspace region.
6	The UTM Administrator role is not implemented.
7	The ability for the UTM Manager role to open, close and modify airspace regions is not fully supported (e.g., a UTM Manager is not able to delete an existing constraint).
8	Aborting operations and abort plans are not fully supported.
9	An operation associated with a ground control station (GCS) that loses its asynchronous connection with the UTM client will not become nonconforming/rogue.
10	Beyond visual line of sight (BVLOS) operation plans should be rejected, but are not, if there is no operational external surveillance system.

APPENDIX A – ACRONYMS AND ABBREVIATIONS

API	Application Programming Interface
ATM	Air Traffic Management
BVLOS	Beyond Visual Line of Sight
CPU	Central Processing Unit
FAA	Federal Aviation Administration
GB	Gigabyte
GCS	Ground Control Station
HTTP	Hypertext Transfer Protocol
ICD	Interface Control Document
LDAP	Lightweight Directory Access Protocol
LDIF	LDAP Data Interchange Format
MB	Megabyte
NASA	National Aeronautics and Space Administration
NextGen	Next Generation Air Transportation System
NOTAM	Notice to Airmen
NPR	NASA Procedural Requirement
OVA	Open Virtual Appliance
RAM	Random Access Memory
SAAM	Space Act Agreement Maker (NASA)
SQL	Structured Query Language
SVD	Software Version Description
TCL	Technical Capability Level
TFR	Temporary Flight Restriction
UAS	Unmanned Aircraft System
URL	Uniform Resource Locator
UTM	UAS Traffic Management
VLOS	Visual Line of Sight
VM	Virtual Machine