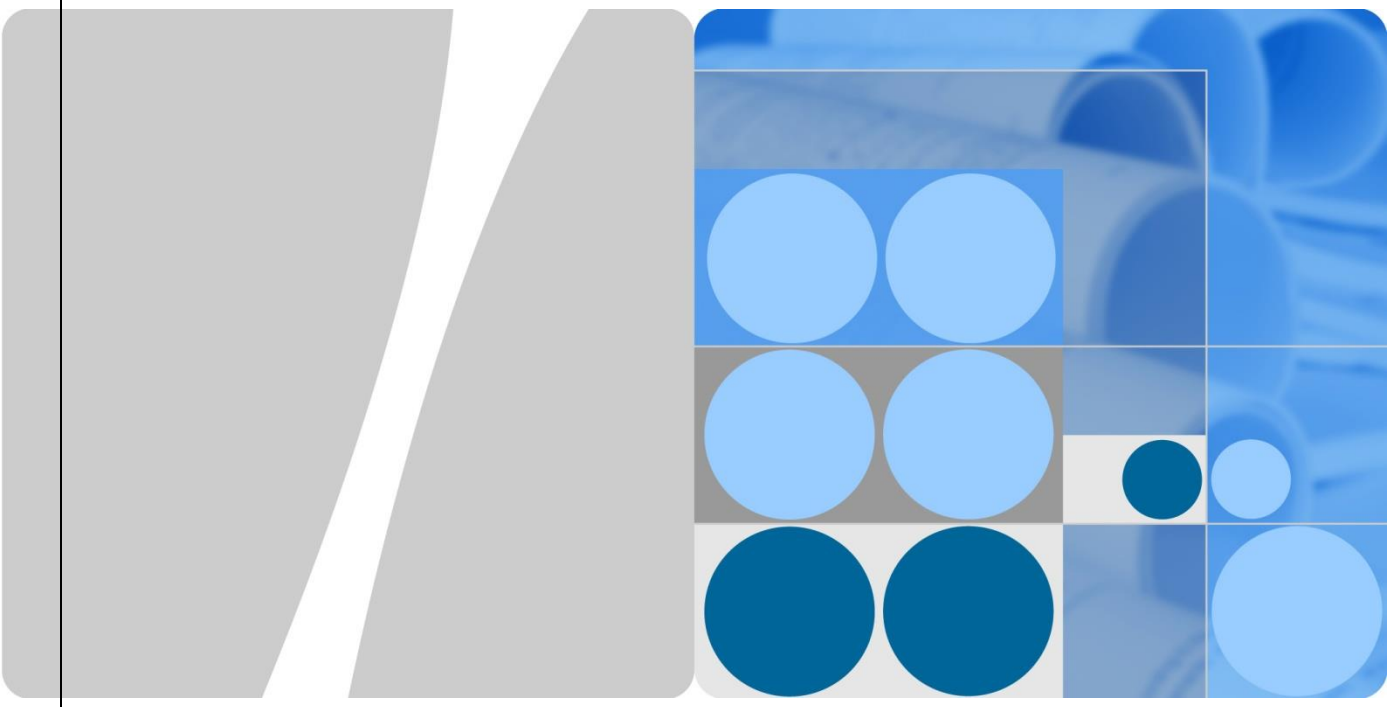

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Security Target

Issue 6.0

Date 2019-10-22

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About This Document

Purpose

This document provides description about ST (Security Target).

Change History

Changes between document issues are cumulative. The latest document issue contains all the changes made in earlier issues.

Date	Revision Version	Section Number	Change Description	Author
2019.6.14	1.0	ALL	Initial Draft	iTrustee Team
2019.07.03	2.0	ALL	Update from evaluator comments	iTrustee Team
2019.08.01	3.0	1.5.2, 3.3	Update from evaluator comments	iTrustee Team
2019.08.29	4.0	3.1, 5.2.1.3, 6.1.3	Update from evaluator comments	iTrustee Team
2019.10.14	5.0	2.3	Update threat definition	iTrustee Team
2019.10.22	6.0	1.5.2	Update TOE image and guidance versions	iTrustee Team

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1 Introduction

This Security Target is for the evaluation of the Huawei iTrustee Operating system, which is a simplified Real-time Operating System (OS) aiming to provide the Trusted Execution Environment (TEE) on the Android platform for managing digital copyright and protecting mobile payment and sensitive data. The TOE version is provided in chap. 1.2.

1.1 Security Target Identification

Security Target Identification	
Document title	CC Huawei iTrustee Software Security Target
Document reference	iTrustee ST
Document version	6.0
Document publication date	22-10-2019
Document author	Huawei Technologies Co., Ltd

1.2 TOE Identification

TOE Identification	
TOE name	Huawei iTrustee
Version	5.0
Developer name	Huawei Technologies Co., Ltd.

Note that the TOE consists of software only. The SoC is out of the scope of the evaluation.

Documentation Identification	
Guidance for Device vendor integrators	
Document title	Huawei iTrustee Preparative Procedures for User
Document reference	Huawei iTrustee Preparative Procedures for User
Document version	V1.1
Document publication date	2019-10-22
Document status	
Document author	Huawei Technologies Co., Ltd.
Guidance for TA developers	
Document title	Huawei iTrustee Operational User Guidance
Document reference	Huawei iTrustee Operational User Guidance
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Document publication date	2019-10-22
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Document author	Huawei Technologies Co., Ltd.
TrustedCore Developer Guide	
Document title	Huawei iTrustee TrustedCore Developer Guide
Document reference	Huawei iTrustee TrustedCore Developer Guide

Documentation Identification	
Document version	V2.3.2
Document publication date	2015-09-12
Document status	
Document author	Huawei Technologies Co., Ltd.

1.3 Conformance claim

1.3.1 CC conformance claim

This Security Target claims to be CC Part2 conformant and CC Part3 extended, with assurance package EAL2, augmented by AVA_TEE.2. The extended components are defined in chap.4.

Common Criteria [CC] version 3.1 revision 5 is the basis for this conformance claim.

1.3.2 PP claim

This Security Target is built using items from the BASE-PP of GlobalPlatform Device Committee TEE Protection Profile Version1.2 [TEE PP], and claims no conformance to any PP.

The TOE defined by this Security Target is the trusted OS, which is one of the components defined by [TEE PP]. The hardware components defined in [TEE PP] are considered as the environment of the TOE, thus the relevant security objectives and SFRs are moved from this Security Target, and new assumptions or objectives are added to the operational environment.

The following table shows the SPDs of the [TEE PP] that are applicable to the current ST:

TOE SPDs	**TEE PP**	**iTrustee Included**
Assumptions		
A.PROTECTION_AFTER_DELIVERY	×	×
A.ROLLBACK	×	×
A.TA_DEVELOPMENT	×	×
A.INTEGRATION		×
A.SECUREBOOT		×
A.SECURE_HARDWARE_PLATFORM		×
Threats		
T.ABUSE_FUNCT	×	×
T.CLONE	×	×
T.FLASH_DUMP	×	×
T.IMPERSONATION	×	×
T.ROGUE_CODE_EXECUTION	×	×
T.PERTURBATION	×	×
T.RAM	×	×
T.RNG	×	×
T.SPY	×	×
T.TEE_FIRMWARE_DOWNGRADE	×	×
T.STORAGE_CORRUPTION	×	×
Organizational Security Policies		
OSP.INTEGRATION_CONFIGURATION	×	×
OSP.SECRETS	×	×

Table 1: TEE PP SPDs vs iTrustee ST

The following table shows the security objectives of the [TEE PP] that are applicable to the current ST:

TOE Objectives	TEE PP	iTrustee Included
Security Objectives for the TOE		
O.CA_TA_IDENTIFICATION	×	×
O.KEYS_USAGE	×	×
O.TEE_ID	×	Changed into OE.TEE_ID
O.INITIALIZATION	×	Changed into O.INITIALIZATION + OE.INITIALIZATION
O.INSTANCE_TIME	×	Changed into OE.INSTANC_TIME
O.OPERATION	×	×
O.RNG	×	Changed into OE.RNG. The RNG is provided by SoC
O.RUNTIME_CONFIDENTIALITY	×	×
O.RUNTIME_INTEGRITY	×	×
O.TA_AUTHENTICITY	×	×
O.TA_ISOLATION	×	×
O.TEE_DATA_PROTECTION	×	×
O.TEE_ISOLATION	×	×
O.TRUSTED_STORAGE	×	×
Security Objectives for the Operational Environment		
OE.INTEGRATION_CONFIGURATION	×	×
OE.PROTECTION_AFTER_DELIVERY	×	×
OE.ROLLBACK	×	×
OE.SECRETS	×	×
OE.TA_DEVELOPMENT	×	×
OE.TEE_ID		×
OE.TRUSTED_HARDWARE		×
OE.RNG		×
OE.INITIALIZATION		×
OE.INSTANCE_TIME	×	×

Table 2: TEE PP Security Objectives vs iTrustee ST

The following table shows the SFRs of the [TEE PP] that are applicable to the iTrustee ST:

SFRs in [TEE PP]	iTrustee Included	Applicable to Hardware/Firmware
1. Identification		
FIA_ATD.1 User attribute definition	×	
FIA_UID.2 User identification before any action	×	
FIA_USB.1 User-subject binding	×	
FMT_SMR.1 Security roles	×	
2.Confidentiality, Integrity and Isolation		
FDP_IFC.2/Runtime Complete information flow control	×	
FDP_IFF.1/Runtime Simple security attributes	×	
FDP_ITT.1/Runtime Basic internal transfer protection		Hardware Only
FDP_RIP.1/Runtime Subset residual information protection	×	
FPT_ITT.1/Runtime Basic internal TSF data transfer protection		Hardware Only
3.Cryptography		

FCS_COP.1 Cryptographic operation	×	
FDP_ACC.1/TA_keys Subset access control	×	
FDP_ACF.1/TA_keys Security attribute based access control	×	
FMT_MSA.1/TA_keys Management of security attributes	×	
FMT_MSA.3/TA_keys Static attribute initialisation	×	
4.Initialization, Operation and Firmware Integrity		
FAU_ARP.1 Security alarms	×	
FDP_SDI.2 Stored data integrity monitoring and action	×	
FPT_FLS.1 Failure with preservation of secure state	×	
FPT_INI.1 TSF initialisation		The whole initialisation was protected by both hardware and firmware
FMT_SMF.1 Specification of Management Functions	×	
FPT_TEE.1 Testing of external entities	×	
5.TEE Identification		
FAU_SAR.1 Audit review	×	
FAU_STG.1 Protected audit trail storage	×	
6.Instance Time		
FPT_STM.1/Instance time Reliable time stamps		Depend on hardware
FCS_RNG.1 Random numbers generation		-Hardware Only
7.Trusted Storage		
FDP_ACC.1/Trusted Storage Subset access control	×	
FDP_ACF.1/Trusted Storage Security attribute based access control	×	
FDP_ROL.1/Trusted Storage Basic rollback	×	
FMT_MSA.1/Trusted Storage Management of security attributes	×	
FMT_MSA.3/Trusted Storage Static attribute initialisation	×	
FDP_ITT.1/Trusted Storage Basic internal transfer protection	×	
Additional SFRs in this ST		
	FCS_CKM.1	
	FCS_CKM.4	

Table 3: SFRs of the [TEE PP] that are applicable to iTrustee ST

1.4 TOE Overview（General product overview）

The TOE type is the Trusted OS, which is only the software part of the Trusted Execution Environment (TEE) defined by [TEE PP]. It is for embedded devices implementing GlobalPlatform TEE specifications (see TEE System Architecture [SA], TEE Internal API [IAPI] and TEE Client API [CAPI]). However, this ST does not claim full functional compliance with GlobalPlatform TEE APIs specifications.

The TOE is an execution environment isolated from any other execution environment, including the usual Rich Execution Environment (REE), and their applications. The TOE hosts a set of Trusted Applications (TA) and provides them with a comprehensive set of security services including: integrity of execution, secure communication with the Client Applications (CA) running in the REE, trusted storage, key management and cryptographic algorithms, time management and arithmetical API.

The TOE comprises:

- Software used to provide the TEE security functionality
- The guidance for the secure usage of the TOE after delivery.

The TOE does not comprise:

- Hardware and firmware used to provide the TEE security functionality
- The Trusted Applications
- The Rich Execution Environment
- The Client Applications.

The TOE can be running on Huawei Mate/P series Mobile Phones, and the necessary Non-TOE hardware in the mobile phone consists at least the following parts:

- Huawei Kirin series SOC, such as Kirin 980 or Kirin 970
- RAM, which can be configured as secure memory and non-secure memory
- ROM, which contain sensitive information for secure boot
- Flash memory, where Android OS and iTrustee stored
- Necessary peripherals such as display screen, Power button etc.

The following Non-TOE software is also required:

- Bootloader
- Bl31 monitor
- EMUI, Huawei customized Android OS
- Device driver for iTrustee in Android
- SDK for Android app to communicate with iTrustee

The TOE enables a wild range of enhanced security services for mobile device, the instances of those use cases are as below:

- Mobile Payment and banking such as Huawei Pay, IFFA, FIDO etc.,
- Device Protection such as Phone Finding Back, Secboot, File Cabinet and File Encryption,
- System Protection such as kernel integrity checking for Android system,
- Digital right management.

In the following, TOE and iTrustee are used interchangeably.

1.5 TOE Description

1.5.1 Architechure Overview：

The TEE is embedded in the device and runs alongside a standard OS or Rich Execution Environment. Figure 1 provides a high level view of the software components of a TEE-enabled device, independently of any hardware architecture.

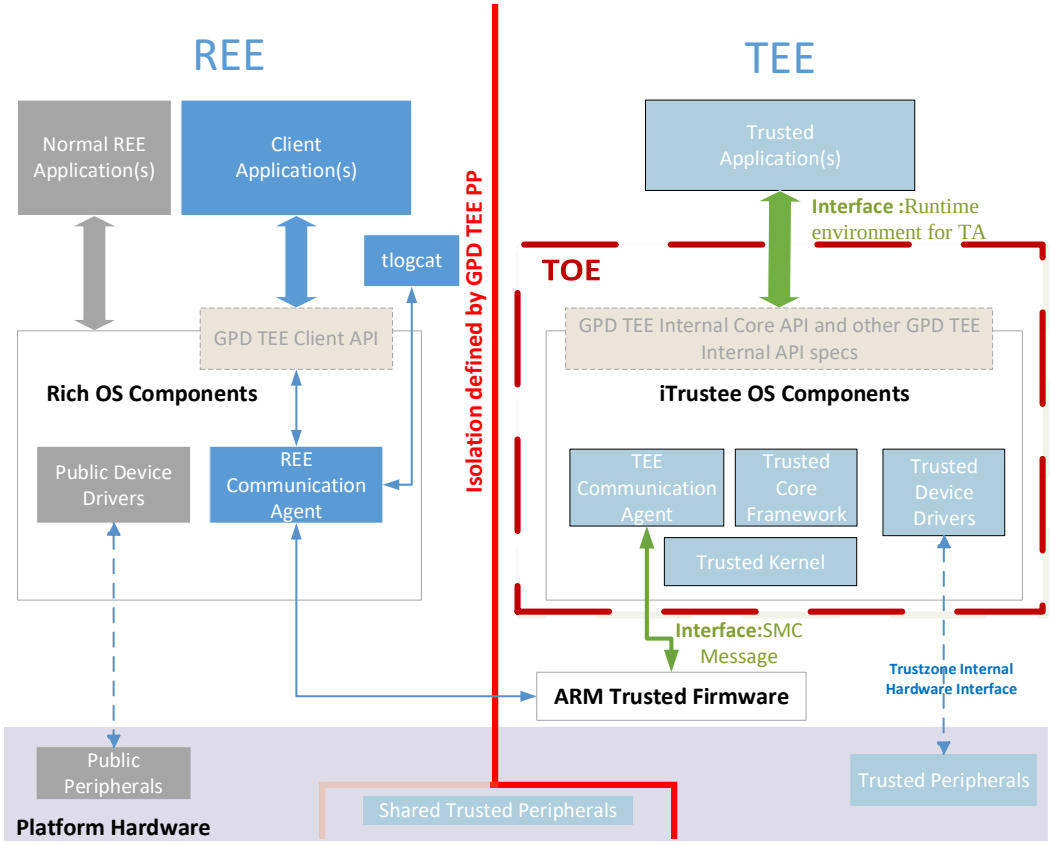

Figure 1: The architecture of a TOE-enabled device

The TEE software architecture identifies two distinct classes of components:

- The Trusted Applications that run on the TEE and use the TEE Internal API
- The Trusted OS Components whose role is to provide communication facilities with the REE software and the system level functionality required by the Trusted Applications, accessible from the TEE Internal API

The REE software architecture identifies also two distinct classes of components:

- The Client Applications which make use of the TEE Client API to access the secure services offered by TAs running on the TEE
- The Rich OS, which provides the TEE Client API and sends requests to the TEE

The TEE software external interface comprises the TEE Internal API (used by the Trusted Applications) and the TEE Communication Agent protocol (used by the REE).

The communication protocol between the REE and the TEE, used below the TEE Client API level, is implementation-dependent, and therefore this ST does not mandate any particular such protocol. The

security targets conformant to this ST shall describe all software interfaces used for communication with the TEE from the REE.

The trusted peripherals including timer modules which are provided by the SoC. The TOE acquires reliable time and RNG from trusted peripherals via the Trustzone internal Hardware interface.

The TOE is composed of four components as below:

iTrustee Component	Description
iTrustee Kernel	iTrustee Kernel provides task creation, memory management, IPC etc.
TEE Communication Agent	TEE communication Agent will send/receive SMC calls to/from REE, resolve SMC messages and forward messages to other components of the TOE.
Trusted Core Framework	Trusted Core Framework will manage the tasks already created.
Trusted Device Drivers	Trusted Device Drivers will talk to Trusted Peripherals, and provide trusted functions to the TOE.

Table 4: TOE components

1.5.2 TOE Physical Scope

The TOE consists of the following components:

Title	Version	Format
iTrustee binary image “SEC_TRUSTEDCORE.IMG”	6.1.0	img
Huawei iTrustee Operational User Guidance	V1.5, 2019-10-22	pdf
Huawei iTrustee Preparative Procedures for User	V1.1, 2019-10-22	pdf
Huawei iTrustee TrustedCore Developer Guide	V2.3.2, 2015-09-12	pdf

Table 5: TOE physical scope

1.5.3 Usage and Major Security Features of the TOE:

The purpose of the TOE is to host and execute Trusted Applications securely, enforcing their mutual isolation and isolation from other execution environments, and ensuring integrity and confidentially of the assets managed by the TOE.

The following sections define the TOE security functionality and the TOE intended usage.

1.5.3.1 TOE Security Functionality

The TOE security functionality in the end-user phase which is in the scope of the evaluation consists of:

- **Protection of TSF** Including TSF secure initialization, TSF failure with preservation of secure state, isolation between REE and TEE, integrity protection of TEE data, and security management

- **Trusted Storage** Providing confidentiality, consistency and integrity protection of TA data; Binding TA data to the TEE;

- **Cryptographic Support** Providing cryptographic service to TA via TEE Internal API. The cryptographic algorithms supported by the TOE are listed in the following table.

Algorithm name	Supported Modes		Key sizes (default bits)	Supported standard
Symmetric ciphers(AES)	ECB CBC CTS XTS CTR		128, 192, 256, 512	FIPS 197 (AES) NIST SP800-38A (ECB, CBC, CTR) IEEE Std 1619-2007 (XTS) NIST SP800-38A Addendum (CTS = CBC-CS3)
Symmetric ciphers (DES/DES3)	ECB CBC		64(DES),128or192(DES3)	FIPS 46 (DES, 3DES) FIPS 81 (ECB, CBC)
Digests	MD5 SHA1 SHA224 SHA256 SHA384 SHA512			RFC 1321 (MD5) FIPS 180-4 (SHA1 SHA224 SHA256 SHA384 SHA512)
MAC(HMAC)	MD5 SHA1 SHA224 SHA256 SHA384 SHA512		block size not exceed（64bytes for SHA-1 and SHA-224/256, 128bytes for SHA-384/512）	RFC 2202 (MD5, SHA1) RFC 4231 (SHA224 SHA256 SHA384 SHA512)
MAC(AES_MAC)	AES_MAC CMAC		128(XCBC_MAC)，256or512(XTS)	NIST SP800-38B (CMAC)
Authen EncryModes	AES_CCM		128, 192, 256	RFC 3610 (CCM)
Asymmetric cipher	encrypt/decrypt	TEE_ALG_RSA_NOPAD TEE_ALG_RSAES_PKCS1_OAEP_MGF1_SHA1 TEE_ALG_RSAES_PKCS1_OAEP_MGF1_SHA224 TEE_ALG_RSAES_PKCS1_OAEP_MGF1_SHA256 TEE_ALG_RSAES_PKCS1_OAEP_MGF1_SHA384 TEE_ALG_RSAES_PKCS1_OAEP_MGF1_SHA512 TEE_ALG_RSAES_PKCS1_V1_5	512, 1024, 2048,3072	PKCS #1 (RSA, PKCS1 v1.5, OAEP) FIPS 180-4 (SHA-1, SHA-2)

	sign/verify	TEE_ALG_RSASSA_PKCS1_V1_5_SHA1 TEE_ALG_RSASSA_PKCS1_V1_5_SHA224 TEE_ALG_RSASSA_PKCS1_V1_5_SHA256 TEE_ALG_RSASSA_PKCS1_V1_5_SHA384 TEE_ALG_RSASSA_PKCS1_V1_5_SHA512 TEE_ALG_RSASSA_PKCS1_PSS_MGF1_SHA1 TEE_ALG_RSASSA_PKCS1_PSS_MGF1_SHA224 TEE_ALG_RSASSA_PKCS1_PSS_MGF1_SHA256 TEE_ALG_RSASSA_PKCS1_PSS_MGF1_SHA384 TEE_ALG_RSASSA_PKCS1_PSS_MGF1_SHA512	512, 1024, 2048,3072	PKCS #1 (RSA, PKCS1 v1.5, PSS) RFC 1321 (MD5) FIPS 180-4 (SHA-1, SHA-2)
Key Derivation	DH		1024, 2048	PKCS #3 FIPS 186-4* ANSI X9.62 NIST SP800-56A, Cofactor Static Unified Model FIPS 186-4* (curve definitions)
ECC	ECDSA ECDH		160, 192, 224, 256, 384 and 521	FIPS 186-4* ANSI X9.62

Table 6: Cryptographic algorithms supported by the TOE

- **User Identification and Authentication** Both CAs and TAs should be identified and authenticated by the TOE before any more actions.

- **Security Audit** The TOE detect potential security violation such as violation of TA data, TA code or TEE data, and generate audit log. The log will be sent to REE.

- **Protection of TA** The TOE provide TA protection during the life cycle from its loading to exiting. For each TA, the TSF will create an isolated user space, and it can’t be accessed by other TAs. TAs can access kernel functions only by internal core API, and everytime it access the kernel, the TSF will perform security policy to ensure correct execution.

- **Communication Data Protection between CA and TA**. TAs running in The TOE provide services to CAs running in the REE world, and CAs can communicate to TAs with specified client API. The TOE will protected the whole communication process and communication data.

The TOE security functionality defines the logical boundary of the TOE. The interfaces of this boundary are the Software External Interface, introduced in sections 1.5.1 respectively.

The security functionality provided by the Trusted Applications is out of the scope of the TOE.

1.5.3.2 TOE Usage

The TOE enables the use of mobile devices for a wide range of services that require security protection, for instance:

- Corporate services: Enterprise devices that enable push e-mail access and office applications give employees a flexibility that requires a secure and fast link to their workplace applications through Virtual Private Networking (VPN), secure storage of their data, and remote management of the device by the IT department.

- Content management: Today's devices offer HD video playback and streaming, mobile TV broadcast reception, and console-quality 3-D games. This functionality often requires content protection, through Digital Rights Management (DRM) or Conditional Access.

- Personal data protection: Devices store increasing amounts of personal information (such as contacts, messages, photos and video clips) and even sensitive data (credentials, passwords, health data, etc.). Secure storage means are required to prevent exposure of this information in the event of loss, theft, or any other adverse event, such as a malware.

- Connectivity protection: Networking through multiple technologies—such as 3G, 4G or Wi-Fi/WiMAX, as well as personal communication means, such as Bluetooth® and Near Field Communication (NFC) — enables the use of mobile devices for peer-to-peer communication and for accessing the Internet. Such access, including web services or remote storage relying on cloud computing, typically uses SSL/TLS or IPsec internet secure protocols. Often the handling of the key material or the client end of the session needs to be secured.

- Mobile financial services: Some types of financial services tend to be targeted at smart phones, such as mobile banking, mobile money transfer, mobile authentication (e.g. use with One-Time Password – OTP technology), mobile proximity payments, etc. These services require secure user authentication and secure transaction, which can be performed by the device potentially in cooperation with a Secure Element.

We refer to the TEE White Paper [WP] for an overview of the main TEE use cases.

1.5.4 Reference Device Life Cycle

The device life cycle outlined here is an overall life cycle from which implementations can deviate according to development, manufacturing and assembly processes. It is split in six phases:

• Phase 1 corresponds to the design of firmware, software and hardware; it covers both TEE and additional components.

• Phase 2 corresponds to the overall design of the hardware platform supporting the TEE.

• Phase 3 corresponds to chipset and other hardware components manufacturing. The root key and material use to generate TEE identifier are set in this phase.

• Phase 4 covers software preparation (linking the TEE software and other software)

• Phase 5 consists of device assembling; it includes any initialization and configuration step necessary to bring the device to a secure state prior delivery to the end-user. Trusted ROM will be formatted in this phase.

• Phase 6 stands for the end-usage of the device.

Figure 2 together with Table 6, show the whole life cycle of TEE-enabled device .

As the TOE is only the software part of the TEE defined in [TEE PP], the related life cycle actors are colored with green in the figure 1.

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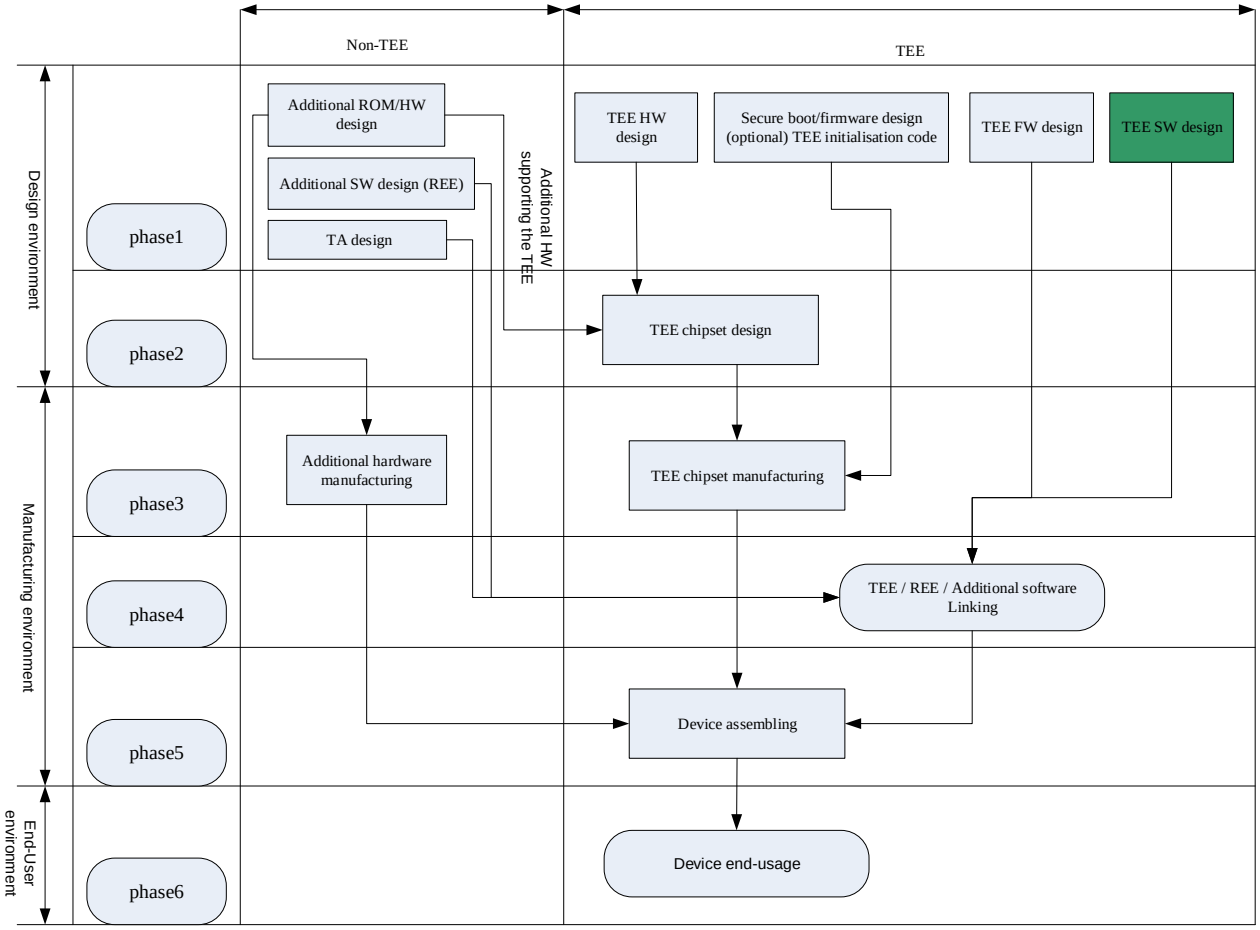

Figure 2: Life Cycle of TEE-enabled Device

Phases	Actors
1 & 2: Firmware / Software / Hardware design	The TEE software(iTrustee) developer • Is in charge of TEE software development and testing compliant with GlobalPlatform specifications • Do not develop the TEE initialization code that instantiates/initializes the TEE (e.g. part of the secure boot code). It is developed by Hardware/firmware team and not included this document. • Specifies the TEE software linking requirements The device manufacturer (not iTrustee) may design additional REE software that will be linked with the TEE in phase 4 to provide REE controlled resources. Both the device manufacturer (not iTrustee) and iTrustee developer may design Trusted Applications that they will integrate in phase 4. The TEE hardware designer is in charge of designing (part of) the processor(s) where the TEE software runs and designing (part of) the hardware security resources used by the TEE. The silicon vendor designs the ROM code and the secure portion of the TEE chipset. If the silicon vendor is not designing the full TEE hardware, the silicon vendor integrates (and potentially augments) the TEE hardware designed by the TEE

	hardware designer(s).
3: TEE manufacturing	The silicon vendor produces the TEE chipset and enables, sets or seeds the root of trust of the TEE. The root key and material use to generate TEE identifier are set in this phase.
4: Software manufacturing	The device manufacturer is responsible for the integration, validation and preparation of the software to load in the product that will include the iTrustee, any pre-installed Trusted Application, and additional software required to use the product (e.g. REE, Client Applications).
5: Device manufacturing	The device manufacturer is responsible for the device assembling and initialization and any other operation on the device (including loading or installation of Trusted Applications) before delivery to the end-user.
6: End-usage phase	The end user gets a device ready for use. The Trusted Applications manager is responsible for the loading, installation, and removal of Trusted Applications post-issuance.

Table 7: Actors in the Device Life Cycle

The phases related to the iTrustee during the whole device life cycle are as below:

Phase1.Software design: including TEE software design and development. Delivering image of iTrustee to device manufacturer.

The other phases are out of scope of this ST.

The TOE doesn’t provides TA management.

2 TOE Security Problem Definition

2.1 Assets

This section presents the assets of the TOE and their properties: authenticity, consistency, integrity, confidentiality, monotonicity, randomness, atomicity, read-only and device binding.

TEE identification

TEE identification data that is globally unique among all GlobalPlatform TEEs whatever the manufacturer, vendor or integrator. This data is typically stored in the Trusted OTP memory of the TEE.

Properties: unique and non-modifiable.

Application Note: The TEE identifier is intended to be public and exposed to any software running on the device, not only to Trusted Applications.

RNG

Random Number Generator.

Properties: unpredictable random numbers, sufficient entropy.

TA code

The code of the installed Trusted Applications. This data is typically stored in external non-volatile memory shared with REE and potentially accessible by it.

Properties: authenticity and consistency (which implies runtime integrity).

TA data and keys

Data and keys managed and stored by a TA using the TEE security services. Data and keys are owned either by the user (the owner of the TEE-enabled device) or by the TA service provider. This data is typically stored in external non-volatile memory shared with REE and potentially accessible by it.

Properties: authenticity, consistency (which implies runtime integrity), atomicity, confidentiality and device binding.

TA instance time

Monotonic time during TA instance lifetime. Not affected by transitions through low power states. Not persistent over TEE reset or TA shut-down.

Properties: monotonicity.

TEE runtime data

Runtime TEE data, including execution variables, runtime context, etc. This data is stored in volatile memory.

Properties: consistency (or integrity as these notions are equivalent for non-persistent data) and confidentiality, including random numbers generated by the TEE.

TEE persistent data

TEE persistent data, including TEE cryptographic keys (for instance keys to authenticate TA code) and TA properties. This data is typically stored in external non-volatile memory shared with REE and potentially accessible by it.

Properties: authenticity, consistency (which implies runtime integrity), confidentiality and device binding.

TEE software initialization code and data

Initialization code and data (for instance cryptographic certificates) used from iTrustee start-up to the complete activation of the TEE security services. Authentication of the TEE is part of its initialization.

Properties: integrity.

TEE storage root of trust

The root of trust of the TEE storage that is used to bind the stored data and keys to the TEE.

Properties: integrity and confidentiality.

2.2 Users / Subjects

There are two kinds of users of the TOE: Trusted Applications, which use the TOE services through the TEE Internal API, and the Rich Execution Environment, which uses the TOE's services exported by the Trusted Applications.

Trusted Application (TA)

All the Trusted Applications running on the TEE are users of the TOE, through the TEE Internal API.

Rich Execution Environment (REE)

The Rich Execution Environment, hosting the standard OS, the TEE Client API and the Client Applications that use the services of the Trusted Applications, is a user of the TOE.

2.3 Threats

This ST targets threats to the TEE assets that arise during the end-usage phase and can be achieved by software means. Attackers are individuals or organizations with remote or physical (local) access to the device embedding the TEE. The user of the device becomes a potential attacker when the TEE holds assets of third parties. The motivations behind the attacks may be very diverse and in general are linked to the Trusted Application running on the TEE. An attacker may, for instance, try to steal content of the device's owner (such as passwords stored in the device) or content of a service provider, or to unduly benefit from TEE or TA services (such as accessing corporate network or performing unauthorized use of DRM content either in the same device or in other devices) or to threaten the reputation of the device/TEE manufacturer or service providers. The impact of an attack depends not only on the value of the individual assets attacked, but, in some cases, on the possibility to reproduce the attack rapidly at low cost: single attacks performed on a given TEE-enabled device have lower impact than massive attacks that reach many devices at the same time.

This ST focuses on non-destructive software attacks that can be easily widespread, for instance through the internet, and constitute a privileged vector for getting undue access to TEE assets without damaging the device itself. In many cases, a software attack involves at least two attackers: the attacker in the identification phase that discovers some vulnerability, conceives malicious software and distributes it, and the attacker at the exploitation phase that effectively exploits the vulnerability by running the malicious software (the end-user or a remote attacker on behalf of the user). The identification and the exploitation attackers may be the same person, in the case of an attack where there is no interest in, or no possibility of spreading the attack widely.

Indeed, different device management and deployment models, as well as services, yield different expected threat models. For devices used in corporate environments, in which the installation of services is controlled, with the end-user having no value in breaking these services, the threat model addresses overall software attacks and vulnerabilities. An attack would indeed not be easily replicable as large-scale access to other such devices is not expected. For unmanaged, personal devices, an attack is more likely to be spreadable as, on the one hand, devices are more widespread and, on the other hand, the end-user himself may have interest in spreading the attack. Therefore, separation between identification and exploitation phases in an attack is key to evaluate such unmanaged devices.

Depending on the way the device is used, different assumptions may be valid regarding the identification phase in terms of means available to the attacker, software or hardware, and in terms of possibility to use more than one device, potentially in a destructive way When identification and exploitation are separate, to address unmanaged devices across which an attack may be easily widespread, the attacker in the identification phase may have software and /or hardware expertise and access to equipment such as oscilloscopes, protocol analyzers, in-circuit emulators, or JTAG debuggers, which allow the attacker to operate at the package interface on the PCB. However, it is not expected that the available attack potential be sufficient to act at deep package and SoC levels.

When identification and exploitation are separate, two main attacker profiles may arise in the exploitation phase:

- **Remote attacker:** This exploitation profile performs the attack on a remotely-controlled device or alternatively makes a downloadable tool that is very convenient to end-users. The attacker retrieves details of the vulnerability identified in the identification phase and outputs such as attack code/executable provided by the identifier. The attacker then makes a remote tool or malware and uses techniques such as phishing to have it downloaded and executed by a victim, or alternatively makes a friendly tool available on the internet. Note that the design of a new malware, trojan, virus, or rooting tool is often performed from an existing base, available on the internet

- **Basic device attacker:** This exploitation profile has physical access to the target device; it is the end-user or someone on his behalf. The attacker retrieves attack code/application from the identifier, guidelines written on the internet on how to perform the attack, downloads and uses tools to jailbreak/root/reflash the device in order to get privileged access to the REE allowing the execution of the exploit. The attacker may be a layman or have some level of expertise but the attacks do not require any specific equipment.

In all cases, the overall attack potential strongly limits the possibility to face advanced attackers performing the exploits. For large-scale exploitation attacks, we refer to Annex A of [TEE PP] for a comprehensive description of the identification and exploitation phases, the applicable attack potential quotation table and a representative set of attacks a TEE may have to face in the field. Due to the somehow more limited interest and possibility of spreading the exploits, attacks against managed devices should only be subset of the attacks in the Annex A of [TEE PP].

The "threats" statement provides the general goal, the assets threatened and in some cases, typical identification and/or exploitation attack paths. Some of the threats constitute in fact steps of longer attack paths related for instance to the disclosure or modification of assets. Nevertheless, they are stated separately to facilitate the tracing of the countermeasures.

T.ABUSE_FUNCT

An attacker accesses TEE functionalities outside of their expected availability range thus violating irreversible phases of the TEE life cycle or state machine.

An attacker manages to instantiate an illegal TEE or to start-up the TEE in an insecure state or to enter an insecure state, allowing the attacker to obtain sensitive data or compromise the TSF (bypass, deactivate or change security services).

Assets threatened directly: TEE initialization code and data (integrity), TEE runtime data (confidentiality, integrity), RNG (confidentiality, integrity), TA code (authenticity, consistency).

Assets threatened indirectly: TA data and keys (confidentiality, authenticity, consistency) including instance time.

Application Note:

Attack paths may consist, for instance, in using commands in unexpected contexts or with unexpected parameters, impersonation of authorized entities or exploiting badly implemented reset functionalities that provides undue privileges.

In particular a fake application running in the Rich OS which masquerades as a security application running in the TEE can grab PINs and passwords and run the real security application on behalf of the user. However, such threat is not countered by the TEE alone and must be taken into account in the design of the use case, for instance by using an applicative authenticated communication channel between the client and the TA.

T.CLONE

An attacker manages to copy TEE related data of a first device on a second device and makes this device accept them as genuine data.

Assets threatened directly: All data and keys (authenticity, device-binding), TEE identification data (authenticity, integrity).

T.FLASH_DUMP

An attacker partially or totally recovers the content of the external Flash in cleartext, thus disclosing sensitive TA and TEE data and potentially allowing the attacker to mount other attacks.

Assets threatened directly (confidentiality, authenticity, consistency): TA data and keys, TEE persistent data.

Application Note:

An attack path consists for instance in performing a (partial) memory dump through the REE, purely via software or with a USB connection.

During identification, another example consists of unsoldering a flash memory and dumping its content, revealing a secret key that provides privileged access to many devices of the same model.

T.IMPERSONATION

An attacker impersonates a Trusted Application to gain unauthorized access to the services and data of another Trusted Application.

Assets threatened directly (confidentiality, integrity): TEE runtime data, RNG.

Assets threatened indirectly: All data and keys (confidentiality, authenticity, consistency).

T.ROGUE_CODE_EXECUTION

An attacker imports malicious code into the TEE to disclose or modify sensitive data.

Assets threatened directly (confidentiality, integrity): TEE runtime data, RNG.

Assets threatened indirectly (confidentiality, authenticity, consistency): All.

Application Note:

Import of code within REE is out of control of the TEE.

T.PERTURBATION

An attacker modifies the behavior of the TEE or a TA in order to disclose or modify sensitive data or to force the TEE or the TA to execute unauthorized services.

Assets threatened directly: TEE initialization code and data (integrity), TEE storage root of trust (confidentiality, integrity), TEE runtime data (confidentiality, integrity), RNG (confidentiality, integrity).

Assets threatened indirectly: All data and keys (confidentiality, authenticity, consistency) including TA instance time.

Application Note:

Unauthorized use of commands (one or many incorrect commands, undefined commands, hidden commands, invalid command sequence) or buffer overflow attacks (overwriting buffer content to modify execution contexts or gaining system privileges) are examples of attack paths. The TEE can also be attacked through REE or TA "programmer errors" that exploit e.g. multi-threading or context/session management or closed sessions or by triggering system resets during execution of commands by the TEE.

T.RAM

An attacker partially or totally recovers RAM content, thus disclosing runtime data and potentially allowing the attacker to interfere with the TEE initialization code and data.

Assets threatened directly: TEE initialization code and data (integrity), TEE storage root of trust (confidentiality, integrity), TEE runtime data (confidentiality, integrity), RNG (confidentiality, integrity).

Assets threatened indirectly: All data and keys (confidentiality, authenticity, consistency).

Application Note:

When the REE and the TEE have shared memory, an attack path consists in the (partial) memory dump (read/write) by the REE. During the identification phase, another example of attack path is to snoop on a memory bus, revealing code that is only decrypted at run-time, and finding a flaw in that code that can be exploited.

T.RNG

An attacker obtains information in an unauthorized manner about random numbers generated by the TEE. This may occur for instance by a lack of entropy of the random numbers generated by the product, or because the attacker forces the output of a partially or totally predefined value.

Loss of unpredictability (the main property of random numbers) is a problem in case they are used to generate cryptographic keys. Malfunctions or premature ageing may also allow getting information about random numbers.

Assets threatened directly (confidentiality, integrity): RNG and secrets derived from random numbers.

T.SPY

An attacker discloses confidential data or keys by means of runtime attacks or unauthorized access to storage locations.

Assets threatened directly (confidentiality): All data and keys, TEE storage root of trust.

Application Note:

Exploitation of side-channels by a CA or TA (e.g. timing), obtention of residual sensitive data (e.g. improperly cleared memory) or use of undocumented or invalid command codes are examples of attack paths. The data may be used to exploit the device it was obtained on, or another device (e.g. shared secret key).

T.TEE_FIRMWARE_DOWNGRADE

An attacker backs up part or all the TEE firmware and restores it later in order to use obsolete TEE functionalities.

Assets threatened directly (integrity): TEE firmware.

Assets threatened indirectly: All data and keys (confidentiality, authenticity, consistency).

T.STORAGE_CORRUPTION

An attacker corrupts all or part of the non-volatile storage used by the TEE including the trusted storage, in an attempt to trigger unexpected behavior from the storage security mechanisms. The ultimate goal of the attack is to disclose and/or modify TEE or TA data and/or code.

Assets threatened directly: TEE storage root of trust (confidentiality, integrity), TEE persistent data (confidentiality, consistency), TEE firmware (authenticity, integrity), TA data and keys (confidentiality, authenticity, consistency), TA instance time (integrity), TA code (authenticity, consistency).

Application Note:

The attack can rely, for instance, on the REE file system or the Flash driver.

2.4 OSP

This section presents the organizational security policies that have to be implemented by the TOE and/or its operational environment.

OSP.INTEGRATION_CONFIGURATION

Integration and configuration of the TOE by the device manufacturer shall rely on guidelines defined by the TOE provider, which fulfill the requirements set in GlobalPlatform TEE specifications and state all the security requirements for the device manufacturer issued from the TOE evaluation.

OSP.SECRETS

Generation, storage, distribution, destruction, injection of secret data in the TEE or any other operation performed outside the TEE shall enforce integrity and confidentiality of these data. This applies to secret data injected before end-usage phase (such as the root of trust of TEE storage) or during the end-usage phase (such as cryptographic private or symmetric keys, confidential data).

2.5 Assumptions

This section states the assumptions that hold on the TEE operational environment. These assumptions have to be met by the operational environment.

A.PROTECTION_AFTER_DELIVERY

It is assumed that the TOE is protected by the environment after delivery and before entering the final usage phase. It is assumed that the persons manipulating the TOE in the operational environment apply the TEE guidelines (e.g. user and administrator guidance, installation documentation, personalization guide). It is also assumed that the persons responsible for the application of the procedures contained in the guides, and the persons involved in delivery and protection of the product have the required skills and are aware of the security issues.

A.ROLLBACK

It is assumed that TA developers do not rely on protection of TEE persistent data, TA data and keys and TA code against full rollback.

A.TA_DEVELOPMENT

TA developers are assumed to be competent and trustworthy individuals who will comply with the TA development guidelines set by the TEE provider. In particular, TA developers are assumed to consider the following principles during the development of the Trusted Applications:

- CA identifiers are generated and managed by the REE, outside the scope of the TEE. A TA must not assume that CA identifiers are genuine
- TAs must not disclose any sensitive data to the REE through any CA (interaction with the CA may require authentication means)
- Data written to memory that are not under the TA instance's exclusive control may have changed at next read
- Reading twice from the same location in memory that is not under the TA instance's exclusive control can return different values.

A.INTEGRATION

It is assumed that the TOE will be installed and configured correctly on the dedicated hardware according to the installation guidance documentation, and all the hardware, firmware components of TEE will be adequately protected. The internal communication data transferred between separated physical components will be protected from disclosure and modification by the TOE environment.

A.SECUREBOOT

It is assumed that the TOE will be started in a secure mode which will ensure:

- the integrity and authenticity of the TOE firmware
- the integrity of the TEE initialization code and data

- the integrity of the storage root of trust
- the integrity of the TEE identification data
- the version of the firmware to prevent downgrade to previous versions

A.SECURE_HARDWARE_PLATFORM

It is assumed that the TOE will run on secure hardware platform defined in [TEE PP].

- TOE is running in an isolated environment based on ARM trustzone, which provides protection of internal data transfer between physically separated components of the TOE and isolation between the REE and TEE.

3 Security Objectives

3.1 Objectives for the TOE

This section states the security objectives for the TOE. Since there is no mandatory split for the realization of the security functions between software and hardware mechanisms, the objectives are close to the goal of the threats and allow any implementation.

The following objectives must be met by the TOE:

O.CA_TA_IDENTIFICATION

The TOE shall provide means to protect the identity of each Trusted Application from usage by another resident Trusted Application and to distinguish Client Applications from Trusted Applications.

Application Note:

Client properties are managed either by the Rich OS or by the Trusted OS and these must ensure that a Client cannot tamper with its own properties in the following sense:

- The Client identity of TOE resident TAs MUST always be determined by the Trusted OS and the determination of whether it is a TA or not MUST be as trustworthy as the Trusted OS itself
- When the Client identity corresponds to a TA, then the Trusted OS MUST ensure that the other Client properties are equal to the properties of the calling TA up to the same level of trustworthiness that the target TA places in the Trusted OS
- When the Client identity does not correspond to a TA, then the Rich OS is responsible for ensuring that the Client Application cannot tamper with its own properties. However this information is not trusted by the Trusted OS.

O.KEYS_USAGE

The TOE shall enforce on cryptographic keys the usage restrictions set by their creators.

O.INITIALIZATION

The TOE shall preserve a secure state through the initialization process of the TEE.

Application Note:

The integrity and authenticity of the firmware(not part of the TOE) is guaranteed by OE.INITIALIZATION.

O.OPERATION

The TEE shall ensure the correct operation of its security functions. In particular, the TEE shall

- Protect itself against abnormal situations caused by programmer errors or violation of good practices by the REE (and the CAs indirectly) or by the TAs
- Control the access to its services by the REE and TAs: The TEE shall check the validity of any operation requested from either the REE or a TA, at any entry point into the TEE
- Enter a secure state upon failure detection, without exposure of any sensitive data.

Application Note:

- Programmer errors or violation of good practices (e.g. that exploit multi-threading or context/session management) might become attack-enablers. The REE may be harmful but < the implementation (TEE) still guarantees the stability and security of TEE > (cf. [CAPI]). In any case, a Trusted Application MUST NOT be able to use a programmer error on purpose to circumvent the security boundaries enforced by an implementation (cf. [IAPI] and [SA])
- Entry points (cf. [SA]): Software in the REE must not be able to call directly to TEE Functions or Trusted Core Framework. The REE software must go through protocols such that the Trusted OS or Trusted Application performs the verification of the acceptability of the operation that the REE software has requested.

O.RUNTIME_CONFIDENTIALITY

The TEE shall ensure that confidential TEE runtime data and TA data and keys are protected against unauthorized disclosure. In particular,

- The TEE shall not export any sensitive data, random numbers or secret keys to the REE
- The TEE shall grant access to sensitive data, random numbers or secret keys only to authorized TAs
- The TEE shall clean up sensitive resources as soon as it can determine that their values are no longer needed.

O.RUNTIME_INTEGRITY

The TEE shall ensure that the the TEE runtime data, the TA code and the TA data and keys are protected against unauthorized modification at runtime when stored in volatile memory.

O.TA_AUTHENTICITY

The TEE shall verify code authenticity of Trusted Applications.

Application Note:

Verification of authenticity of TA code can be performed together with the verification of TEE firmware if both are bundled together or during loading of the code in volatile memory. In this scenario the authenticity of the TA code is guaranteed by OE.INITIALIZATION.

O.TA_ISOLATION

The TEE shall isolate the TAs from each other: Each TA shall access its own execution and storage space, which is shared among all the instances of the TA but separated from the spaces of any other TA.

Application Note:

This objective contributes to the enforcement of the confidentiality and the integrity of the TEE.

O.TEE_DATA_PROTECTION

The TEE shall ensure the authenticity, consistency and confidentiality of TEE persistent data.

O.TEE_ISOLATION

The TEE shall prevent the REE and the TAs from accessing the TEE own execution and storage space and resources.

Application Note:

This objective contributes to the enforcement of the correct execution of the TEE. Note that resource allocation can change during runtime as long as it does not break isolation between TEE resources during their usage and REE/TAs.

O.TRUSTED_STORAGE

The TEE shall provide Trusted Storage services for persistent TA general-purpose data and key material such that:

- The confidentiality of the stored data and keys is enforced
- The authenticity of the stored data and keys is enforced
- The consistency of each TA stored data and keys is enforced
- The atomicity of the operations that modify the storage is enforced.

The TEE Trusted Storage shall be bound to the hosting device, which means that the storage space must be accessible or modifiable only by authorized TAs running on the same TEE and device as when the data was created.

The table below summarizes which security objectives relate to the assets stored in non-volatile and/or volatile memory.

Asset	In non-volatile memory	In volatile memory
TEE runtime data	N/A	O.RUNTIME_INTEGRITY
TA code	O.TA_AUTHENTICITY	O.RUNTIME_INTEGRITY
TA data and keys	O.TRUSTED_STORAGE	O.RUNTIME_INTEGRITY
TEE persistent data	O.TEE_DATA_PROTECTION	O.TEE_DATA_PROTECTION

Table 8: Assets store location

3.2 Objectives for the Operational Environment

This section states the security objectives for the TOE operational environment covering all the assumptions and the organizational security policies that apply to the environment.

The following security objectives apply to any TOE operational environment that does not implement any additional security feature.

OE.INTEGRATION_CONFIGURATION

Integration and configuration of the TEE by the device manufacturer shall rely on guidelines defined by the TOE provider that fulfill the requirements set in GlobalPlatform TEE specifications and state all the security requirements for the device manufacturer issued from the TOE evaluation.

The TOE shall be installed and configured correct to ensure the TOE running in a secure state. The process of TEE identifier generating shall ensure statistical uniqueness of the TEE identifier.

OE.PROTECTION_AFTER_DELIVERY

The TOE shall be protected by the environment after delivery and before entering the final usage phase. The persons manipulating the TOE in the operational environment shall apply the TEE guidance (e.g. user and administrator guidance, installation documentation, personalization guide).

The persons responsible for the application of the procedures contained in the guides, and the persons involved in delivery and protection of the product have the required skills and are aware of the security issues.

Application Note:

The certificate is valid only when the guides are applied. For instance, for installation, prepersonalization or personalization guides, only the described set-up configurations or personalization profiles are covered by the certificate.

OE.ROLLBACK

The TA developer shall take into account that the TEE does not provide full rollback protection of TEE persistent data, TA data and keys and TA code.

OE.SECRETS

Management of secret data (e.g. generation, storage, distribution, destruction, loading into the product of cryptographic private keys, symmetric keys, user authentication data) performed outside the TEE shall enforce integrity and confidentiality of these data.

OE.TA_DEVELOPMENT

TA developers shall comply with the TA development guidelines set by the TEE provider. In particular, TA developers shall apply the following security recommendations during the development of the Trusted Applications:

- CA identifiers are generated and managed by the REE, outside the scope of the TEE; TAs do not assume that CA identifiers are genuine
- TAs do not disclose any sensitive data to the REE through any CA (interaction with the CA may require authentication means)
- TAs shall not assume that data written to a shared buffer can be read unchanged later on; TAs should always read data only once from the shared buffer and then validate it
- TAs should copy the contents of shared buffers into TA instance-owned memory whenever these contents are required to be constant.
- TA developers should apply for TA identifiers from the TOE manufacture before deploying the TA into the TOE. All of the TA identifiers are generated, issued and managed by the TOE manufacture.

OE.INITIALIZATION

The TEE shall be started through a secure initialization process that ensures:

- the integrity of the TEE initialization code and data used to load the TEE firmware
- the authenticity and confidentiality of the TEE firmware

- that the TEE is bound to the SoC of the device. In particular, the TEE shall protect the TEE firmware against downgrade attacks.

After completion of the initialization process the TOE is running in a secure state.

Application Note:

The fact that the process is bound to the SoC means that the root of trust for the TEE data cannot be modified or tampered with (cf. [SA]).

OE.TEE_ID

The TEE shall ensure the TEE identifier is non-modifiable and provide means to retrieve this identifier.

OE.RNG

The hardware of TEE shall provide a random number generator's quality. Random numbers shall not be predictable and shall have sufficient entropy.

OE.TRUSTED_HARDWARE

Trusted hardware which the TOE runs on shall provide essential security mechanisms to ensure the TOE runs in a secure state and provide security functions needed by the TOE SFRs.

Additionally, the trusted hardware provides protection of the communication between physically separated parts of the TOE.

The security functions supported/provided by trusted hardware are reliable time stamps, RNG.

Application Note:

Trusted hardware will provide the TOE with security mechanisms to implement trust storage function and more informations to implement log service when error is detected.

Trusted hardware includes Huawei Kirin series Soc, secure storage, RAM mapped to secure world etc.

OE.INSTANCE_TIME

The TEE Hardware shall provide TA instance time and shall ensure that this time is monotonic during TA instance lifetime - from TA instance creation until the TA instance is destroyed - and not impacted by transitions through low power states.

3.3 Security Objectives Rationale

3.3.1 Coverage

The following tables provide mappings between TOE SPD and Security Objectives.

Threats	Security Objectives
T.ABUSE_FUNCT	O.INITIALIZATION, O.OPERATION, O.RUNTIME_CONFIDENTIALITY, O.RUNTIME_INTEGRITY, O.TEE_DATA_PROTECTION, O.TEE_ISOLATION, OE.TA_DEVELOPMENT, O.KEYS_USAGE, O.TA_AUTHENTICITY,

	OE.INITIALIZATION, OE.TRUSTED_HARDWARE
T.CLONE	OE.TEE_ID, O.INITIALIZATION, OE.INITIALIZATION, O.RUNTIME_CONFIDENTIALITY, O.RUNTIME_INTEGRITY, O.TEE_DATA_PROTECTION, O.TRUSTED_STORAGE, OE.INTEGRATION_CONFIGURATION, OE.TRUSTED_HARDWARE
T.FLASH_DUMP	O.TRUSTED_STORAGE, OE.TRUSTED_HARDWARE
T.IMPERSONATION	O.CA_TA_IDENTIFICATION, O.OPERATION, O.RUNTIME_INTEGRITY, OE.TRUSTED_HARDWARE
T.ROGUE_CODE_EXECUTION	O.OPERATION, O.RUNTIME_CONFIDENTIALITY, O.RUNTIME_INTEGRITY, O.TEE_DATA_PROTECTION, O.TRUSTED_STORAGE, OE.INTEGRATION_CONFIGURATION, OE.PROTECTION_AFTER_DELIVERY, O.TA_AUTHENTICITY, O.INITIALIZATION, OE.INITIALIZATION, OE.TRUSTED_HARDWARE
T.PERTURBATION	O.INITIALIZATION, OE.INITIALIZATION, O.OPERATION, OE.INSTANCE_TIME, O.RUNTIME_CONFIDENTIALITY, O.RUNTIME_INTEGRITY, O.TA_ISOLATION, O.TEE_DATA_PROTECTION, O.TEE_ISOLATION, O.TA_AUTHENTICITY
T.RAM	O.INITIALIZATION, OE.INITIALIZATION, O.RUNTIME_CONFIDENTIALITY, O.RUNTIME_INTEGRITY, O.TA_ISOLATION, O.TEE_ISOLATION, OE.TRUSTED_HARDWARE
T.RNG	OE.INITIALIZATION, O.RUNTIME_CONFIDENTIALITY, OE.RNG O.RUNTIME_INTEGRITY, OE.TRUSTED_HARDWARE
T.SPY	O.RUNTIME_CONFIDENTIALITY, O.TA_ISOLATION, O.TEE_ISOLATION, O.TRUSTED_STORAGE, OE.TRUSTED_HARDWARE
T.TEE_FIRMWARE_DOWNGRADE	O.INITIALIZATION, OE.INITIALIZATION, OE.INTEGRATION_CONFIGURATION, OE.PROTECTION_AFTER_DELIVERY
T.STORAGE_CORRUPTION	O.OPERATION, OE.ROLLBACK, O.TEE_DATA_PROTECTION,

	O.TRUSTED_STORAGE, O.TA_AUTHENTICITY, O.INITIALIZATION, OE.INITIALIZATION, OE.TRUSTED_HARDWARE

Table 9: Threats and Security Objectives – Coverage

Security Objectives	Threats
O.CA_TA_IDENTIFICATION	T.IMPERSONATION
O.KEYS_USAGE	T.ABUSE_FUNCT
OE.TEE_ID	T.CLONE
O.INITIALIZATION	T.ABUSE_FUNCT, T.CLONE, T.ROGUE_CODE_EXECUTION, T.PERTURBATION, T.RAM, T.TEE_FIRMWARE_DOWNGRADE, T.STORAGE_CORRUPTION
OE.INSTANCE_TIME	T.PERTURBATION
O.OPERATION	T.ABUSE_FUNCT, T.IMPERSONATION, T.ROGUE_CODE_EXECUTION, T.PERTURBATION, T.STORAGE_CORRUPTION
O.RUNTIME_CONFIDENTIALITY	T.ABUSE_FUNCT, T.CLONE, T.ROGUE_CODE_EXECUTION, T.PERTURBATION, T.RAM, T.RNG, T.SPY
O.RUNTIME_INTEGRITY	T.ABUSE_FUNCT, T.CLONE, T.IMPERSONATION, T.ROGUE_CODE_EXECUTION, T.PERTURBATION, T.RAM, T.RNG
O.TA_AUTHENTICITY	T.ABUSE_FUNCT, T.ROGUE_CODE_EXECUTION, T.PERTURBATION, T.STORAGE_CORRUPTION
O.TA_ISOLATION	T.PERTURBATION, T.RAM, T.SPY
O.TEE_DATA_PROTECTION	T.ABUSE_FUNCT, T.CLONE, T.ROGUE_CODE_EXECUTION, T.PERTURBATION, T.STORAGE_CORRUPTION
O.TEE_ISOLATION	T.ABUSE_FUNCT, T.PERTURBATION, T.RAM, T.SPY
O.TRUSTED_STORAGE	T.CLONE, T.FLASH_DUMP, T.ROGUE_CODE_EXECUTION, T.SPY, T.STORAGE_CORRUPTION
OE.INTEGRATION_CONFIGURATION	T.ROGUE_CODE_EXECUTION, T.TEE_FIRMWARE_DOWNGRADE
OE.PROTECTION_AFTER_DELIVE	T.ROGUE_CODE_EXECUTION,

RY	T.TEE_FIRMWARE_DOWNGRADE
OE.ROLLBACK	T.STORAGE_CORRUPTION
OE.SECRETS	
OE.TA_DEVELOPMENT	T.ABUSE_FUNCT
OE.INITIALIZATION	T.ABUSE_FUNCT, T.CLONE, T.ROGUE_CODE_EXECUTION, T.PERTURBATION, T.RAM, T.RNG, T.TEE_FIRMWARE_DOWNGRADE, T.STORAGE_CORRUPTION
OE.RNG	T.RNG
OE.TRUSTED_HARDWARE	T.ABUSE_FUNCT, T.CLONE, T.FLASH_DUMP, T.IMPERSONATION, T.ROGUE_CODE_EXECUTION, T.RAM, T.SPY, T.STORAGE_CORRUPTION, T.RNG

Table 10: Security Objectives and Threats – Coverage

Organizational Security Policies	Security Objectives
OSP.INTEGRATION_CONFIGURATION	OE.INTEGRATION_CONFIGURATION
OSP.SECRETS	OE.SECRETS

Table 11: OSPs and Security Objectives - Coverage

Security Objectives	Organizational Security Policies
O.CA_TA_IDENTIFICATION	
O.KEYS_USAGE	
OE.TEE_ID	
O.INITIALIZATION	
OE.INSTANCE_TIME	
O.OPERATION	
O.RUNTIME_CONFIDENTIALITY	
O.RUNTIME_INTEGRITY	
O.TA_AUTHENTICITY	
O.TA_ISOLATION	
O.TEE_DATA_PROTECTION	
O.TEE_ISOLATION	
O.TRUSTED_STORAGE	
OE.INTEGRATION_CONFIGURATI	OSP.INTEGRATION_CONFIGURATION

ON	
OE.PROTECTION_AFTER_DELIVERY	
OE.ROLLBACK	
OE.SECRETS	OSP.SECRETS
OE.TA_DEVELOPMENT	
OE.INITIALIZATION	
OE.RNG	
OE.TRUSTED_HARDWARE	

Table 12: Security Objectives and OSPs – Coverage

Assumptions	Security Objectives for the Operational Environment
A.PROTECTION_AFTER_DELIVERY	OE.PROTECTION_AFTER_DELIVERY
A.ROLLBACK	OE.ROLLBACK
A.TA_DEVELOPMENT	OE.TA_DEVELOPMENT
A.SECUREBOOT	OE.INITIALIZATION
A.INTEGRATION	OE.INTEGRATION_CONFIGURATION
A.SECURE_HARDWARE_PLATFORM	OE.TRUSTED_HARDWARE

Table 13: Assumptions and Security Objectives for the Operational Environment – Coverage

Security Objectives for the Operational Environment	Assumptions
OE.INTEGRATION_CONFIGURATION	A.INTEGRATION
OE.PROTECTION_AFTER_DELIVERY	A.PROTECTION_AFTER_DELILVERY
OE.ROLLBACK	A.ROLLBACK
OE.SECRETS	
OE.TA_DEVELOPMENT	A.TA_DEVELOPMENT
OE.TRUSTED_HARDWARE	A.SECURE_HARDWARE_PLATFORM
OE.INITIALIZATION	A.SECUREBOOT

Table 14: Security Objectives for the Operational Environment and Assumptions - Coverage

3.3.2 Rationale

3.3.2.1 Threats

T.ABUSE_FUNCT The combination of the following objectives ensures protection against abuse of functionality:

- o O.INITIALIZATION and OE.INITIALIZATION ensures that the TEE security functionality is correctly initialized
- o O.OPERATION ensures correct operation of the security functionality and a proper management of failures
- o O.RUNTIME_CONFIDENTIALITY prevents exposure of confidential data
- o O.RUNTIME_INTEGRITY ensures protection against unauthorized modification of security functionality at runtime
- o O.TA_AUTHENTICITY ensures that the authenticity of TA code is verified
- o O.TEE_DATA_PROTECTION ensures that the data used by the TEE are authentic and consistent
- o O.TEE_ISOLATION enforces the separation between the TEE and the outside (REE and TAs)
- o O.KEYS_USAGE controls the usage of cryptographic keys
- o OE.TA_DEVELOPMENT enforces TA development principles, which are meant in particular to prevent disclosing information or performing modifications upon request of unauthorized entities
- o OE.TRUSTED_HARDWARE ensures protection of the communication between physically separated parts of the TOE.

T.CLONE The combination of the following objectives ensures protection against cloning:

- o OE.TEE_ID provides the unique TEE identification means
- o O.INITIALIZATION and OE.INITIALIZATION ensure that the TEE is bound to the SoC of the device
- o O.RUNTIME_CONFIDENTIALITY prevents exposure of confidential data, in particular TSF data used to bind the TEE to the device
- o O.RUNTIME_INTEGRITY prevents against unauthorized modification at runtime of security functionalities or data used to detect or prevent cloning
- o O.TEE_DATA_PROTECTION prevents the TEE from using TEE data that is inconsistent or not authentic
- o O.TRUSTED_STORAGE ensures that the trusted storage is bound to the device and prevents the TEE from using data that is inconsistent or not authentic
- o OE.INTEGRATION_CONFIGURATION ensures that the TEE identifier is in fact unique when generated outside the TOE
- o OE.TRUSTED_HARDWARE ensures protection of the communication between physically separated parts of the TOE.

T.FLASH_DUMP The combination of the following objectives ensures protection against flash dump attacks:

- o O.TRUSTED_STORAGE ensures the confidentiality of the data stored in external memory.
- o OE.TRUSTED_HARDWARE ensures protection of the communication between physically separated parts of the TOE.

T.IMPERSONATION The combination of the following objectives ensures protection against application impersonation attacks:

- o O.CA_TA_IDENTIFICATION ensures the protection of Client identities and the possibility to distinguish Client Applications and Trusted Applications
- o O.OPERATION ensures the verification of Client identities before any operation on their behalf
- o O.RUNTIME_INTEGRITY prevents against unauthorized modification of security functionality at runtime
- o OE.TRUSTED_HARDWARE ensures protection of the communication between physically separated parts of the TOE.

T.ROGUE_CODE_EXECUTION The combination of the following objectives ensures protection against import of malicious code:

- o O.INITIALIZATION and OE.INITIALIZATION ensures that the TEE security functionality is correctly initialized and the integrity of TEE firmware
- o O.OPERATION ensures correct operation of the security functionality
- o O.RUNTIME_CONFIDENTIALITY covers runtime TEE data which might influence the behavior of the TEE
- o O.TA_AUTHENTICITY ensures that the authenticity of TA code is verified
- o O.RUNTIME_INTEGRITY ensures protection against unauthorized modification of security functionality at runtime
- o O.TEE_DATA_PROTECTION covers persistent TEE data which might influence the behavior of the TEE
- o O.TRUSTED_STORAGE ensures protection of the storage from which code might be imported
- o OE.INTEGRATION_CONFIGURATION covers the import of foreign code in a phase other than the end-user phase
- o OE.PROTECTION_AFTER_DELIVERY covers the import of foreign code in a phase other than the end-user phase
- o OE.TRUSTED_HARDWARE ensures protection of the communication between physically separated parts of the TOE.

T.PERTURBATION The combination of the following objectives ensures protection against perturbation attacks:

- o O.INITIALIZATION and OE.INITIALIZATION ensures that the TEE security functionality is correctly initialized
- o O.OPERATION ensures correct operation of the security functionality and a proper management of failures

o O.RUNTIME_CONFIDENTIALITY covers runtime TEE data which might influence the behavior of the TEE

o O.TA_AUTHENTICITY ensures that the authenticity of TA code is verified

o O.RUNTIME_INTEGRITY ensures protection against unauthorized modification of security functionality at runtime

o O.TA_ISOLATION ensures the separation of the TA

o O.TEE_DATA_PROTECTION covers persistent TEE data which might influence the behavior of the TEE

o O.TEE_ISOLATION enforces the separation between the TEE and the outside (REE and TAs).

o OE.INSTANCE_TIME ensures the reliability of instance time stamps

T.RAM The combination of the following objectives ensures protection against RAM attacks:

o O.INITIALIZATION and OE.INITIALIZATION ensures that the TEE security functionality is correctly initialized and that the initialization process is protected from the REE

o O.RUNTIME_CONFIDENTIALITY prevents exposure of confidential data at runtime

o O.RUNTIME_INTEGRITY protects against unauthorized modification of code and data at runtime

o O.TA_ISOLATION provides a memory barrier between TAs

o O.TEE_ISOLATION provides a memory barrier between the TEE and the REE

o OE.TRUSTED_HARDWARE ensures protection of the communication between physically separated parts of the TOE.

T.RNG The combination of the following objectives ensures protection of the random number generation:

o OE.INITIALIZATION ensures the correct initialization of the TEE security functions, in particular the RNG

o OE.RNG and OE.TRUSTED_HARDWARE ensure that random numbers are unpredictable, have sufficient entropy and are not disclosed

o O.RUNTIME_CONFIDENTIALITY ensures that confidential data is not disclosed

o O.RUNTIME_INTEGRITY protects against unauthorized modification, for instance to force the output of the RNG.

T.SPY The combination of the following objectives ensures protection against disclosure:

o O.RUNTIME_CONFIDENTIALITY ensures protection of confidential data at runtime

o O.TA_ISOLATION ensures the separation between TAs

o O.TEE_ISOLATION ensures that neither REE nor TAs can access TEE data

o O.TRUSTED_STORAGE ensures that data stored in the trusted storage locations is accessible by the TA owner only

o OE.TRUSTED_HARDWARE ensures protection of the communication between physically separated parts of the TOE.

T.TEE_FIRMWARE_DOWNGRADE The combination of the following objectives ensures protection against TEE firmware downgrade:

- o O.INITIALIZATION and OE.INITIALIZATION ensures that the firmware that is executed is the version that was intended
- o OE.INTEGRATION_CONFIGURATION ensures that the firmware installed in the device is the version that was intended
- o OE.PROTECTION_AFTER_DELIVERY ensures that the firmware has not been modified after delivery.

T.STORAGE_CORRUPTION The combination of the following objectives ensures protection against corruption of non-volatile storage:

- o O.OPERATION ensures the correct operation of the TEE security functionality, including storage
- o O.TEE_DATA_PROTECTION ensures that stored TEE data are genuine and consistent
- o O.TRUSTED_STORAGE enforces detection of corruption of the TA's storage
- o O.TA_AUTHENTICITY ensures that the authenticity of TA code is verified
- o O.INITIALIZATION and OE.INITIALIZATION ensures that the firmware that is executed is the version that was intended
- o OE.ROLLBACK states the limits of the properties enforced by the TSF
- o OE.TRUSTED_HARDWARE ensures protection of the communication between physically separated parts of the TOE.

3.3.2.2 OSPs

OSP.INTEGRATION_CONFIGURATION The objective OE.INTEGRATION_CONFIGURATION directly covers this OSP.

OSP.SECRETS The objective OE.SECRETS directly covers this OSP.

3.3.2.3 Assumptions

A.PROTECTION_AFTER_DELIVERY The objective OE.PROTECTION_AFTER_DELIVERY directly covers this assumption.

A.ROLLBACK The objective OE.ROLLBACK directly covers this assumption.

A.TA_DEVELOPMENT The objective OE.TA_DEVELOPMENT directly covers this assumption.

A.INTEGRATION The combination of the following objectives covers this assumption:

- o OE.INTEGRATION_CONFIGURATION ensures that the hardware, firmware and other components will be installed and configured correctly in the device.
- o OE.INITIALIZATION ensures that the firmware installed in the device is the version that was intended.

A.SECUREBOOT The objective OE.INITIALIZATION directly covers this assumption.

A.SECURE_HARDWARE_PLATFORM The objective OE.TRUSTED_HARDWARE directly covers this assumption

4 Extended Components Definition

4.1 Extended Families

4.1.1 Extended Family AVA_TEE - Vulnerability analysis of TEE

4.1.1.1 Description

TEE vulnerability analysis is an assessment to determine whether potential vulnerabilities identified in the TEE could allow attackers to violate the SFRs and thus to perform unauthorized access or modification to data or functionality.

The potential vulnerabilities may be identified either during the evaluation of the development, manufacturing or assembling environments, during the evaluation of the TEE specifications and guidance, during anticipated operation of the TEE components or by other methods, for instance statistical methods.

The family 'Vulnerability analysis of TEE (AVA_TEE)' defines requirements for evaluator independent vulnerability search and penetration testing of TEE.

The main characteristic of the new family, which is almost identical to AVA_VAN, is to introduce the TEE-specific attack potential scale defined in Annex A.1 of [TEE PP]. This annex also provides the TEE attack potential calculation table and a catalogue of TEE-specific attack methods. In this current version of the ST, only one level of the TEE-specific attack potential scale, namely TEE-Low, is used, in the component AVA_TEE.2.

By comparison with the family AVA_VAN, the standard component AVA_VAN.2 of this family provides a good level of assurance against SW-only attacks on TEE, for instance mobile application malware that is spreading through uncontrolled application stores, exploiting already known SW vulnerabilities.

Such malwares can usually defeat REE security, and the TEE must resist such attacks. AVA_VAN.2 is well-fit for devices managed within a controlled environment, e.g. fleets of corporate devices, for services against which the end-user may not have any interest in attacking.

This choice of a TEE-specific attack potential scale in AVA_TEE.2 is motivated by additional assurance with protection against easily spreadable attacks that may result from costly vulnerability identification. Such attack paths have been used in some cases against mobile devices, and are usual in market segments such as game consoles or TV boxes, where the expected return on investment is higher, and in which the end-user has an interest to perform the exploit. In order to reach this goal, AVA_TEE.2 splits attacks quotation in the two phases identification and exploitation (as done for smart cards) and defines

the attacker potential TEE-Low (which is comparable to the Enhanced-Basic level of the smart cards quotation table).

The family 'Vulnerability analysis of TEE (AVA_TEE)' is defined as follows. Underlined text stands for replacements with respect to AVA_VAN.2, thus allowing easy traceability.

4.1.1.2 Extended Components

4.1.1.2.1 Extended Component AVA_TEE.2

Description

A vulnerability analysis is performed by the evaluator to ascertain the presence of potential vulnerabilities.

The evaluator performs penetration testing on the TEE to confirm that the potential vulnerabilities cannot be exploited in the operational environment of the TEE. Penetration testing is performed by the evaluator assuming an attack potential of TEE-Low.

Definition

AVA_TEE.2 TEE vulnerability analysis

AVA_TEE.2.1D The developer shall provide the TOE for testing.

AVA_TEE.2.1C The TOE shall be suitable for testing.

AVA_TEE.2.1E The evaluator shall confirm that the information provided meets all requirements for content and presentation of evidence.

AVA_TEE.2.2E The evaluator shall perform a search of public domain sources to identify potential vulnerabilities in the TOE.

AVA_TEE.2.3E The evaluator shall perform an independent vulnerability analysis of the TOE using the guidance documentation, functional specification, TOE design and security architecture description to identify potential vulnerabilities in the TOE.

AVA_TEE.2.4E The evaluator shall conduct penetration testing, based on the identified potential vulnerabilities, to determine that the TOE is resistant to attacks performed by an attacker possessing TEE-Low attack potential.

Dependencies: ADV_ARC.1 Security architecture description

ADV_FSP.2 Security-enforcing functional specification

ADV_TDS.1 Basic design

AGD_OPE.1 Operational user guidance

AGD_PRE.1 Preparative procedures

5 Security Requirements

5.1 Conventions

The conventions used in descriptions of the SFRs are as follows:

(1) Assignment: Indicated with *italicized* text;
(2) Refinement: Indicated with **bold text** and ~~strikethroughs~~, if necessary;
(3) Selection: Indicated with underlined text;
(4) Assignment within a Selection: Indicated with *italicized and underlined text*;
(5) Iteration: Indicated by appending the iteration number in parenthesis, e.g. (1), (2), (3) and /or by adding a string starting with "/";
(6) Application Notes are marked as '*Application Note:*' formatted with *italicized* text;
(7) References: Indicated with [square brackets].

5.2 TOE Security Functional Requirements

This chapter provides the set of Security Functional Requirements (SFRs) the TOE has to enforce in order to fulfill the security objectives.

5.2.1 Definitions

This Security Target uses the following security functional components defined in CC Part 2 [CC2]:

- FAU_ARP.1 Security alarms
- FAU_SAR.1 Audit review
- FAU_STG.1 Audit event storage
- FCS_COP.1 Cryptographic operation
- FIA_ATD.1 User attribute definition
- FIA_UID.2 User identification before any action
- FIA_USB.1 User-subject binding
- FDP_ACC.1 Subset access control
- FDP_ACF.1 Security attribute based access control
- FDP_IFC.2 Complete information flow control
- FDP_IFF.1 Simple security attributes
- FDP_RIP.1 Subset residual information protection

- FDP_ROL.1 Basic rollback
- FDP_SDI.2 Stored data integrity monitoring and action
- FMT_MSA.1 Management of security attributes
- FMT_MSA.3 Static attribute initialization
- FMT_SMR.1 Security roles
- FMT_SMF.1 Management functions
- FPT_FLS.1 Failure with preservation of secure state
- FPT_TEE.1 Testing of external entities
- FCS_CKM.1 Cryptographic key generation
- FCS_CKM.4 Cryptographic key destruction

The statement of the security functional requirements rely on the following characterization of the TEE in terms of users, subjects, objects, information, user data, TSF data, operations and their security attributes (cf. CC Part 1 [CC1] for the definition of these notions).

Users stand for entities outside the TOE:

- Client Applications (CA), with security attribute "CA_identity" (CA identifier)
- Trusted Applications (TA), with security attribute "TA_identity" (TA identifier), "TA_properties".

Subjects stand for active entities inside the TOE:

- S.TA_INSTANCE: any TA instance with security attribute "TA_identity" (TA identifier)
- S.TA_INSTANCE_SESSION: any session within a given TA instance, with security attribute "client_identity" (CA identifier)
- S.API: the TEE Internal API, with security attributes "caller" (TA identifier)
- S.RESOURCE: Software component which may be used alternatively by the TEE or the REE, with security attribute "state" (TEE/REE). E.g. cache, registers. Note: When the state is REE, the TEE may access the resource. The communication buses are not considered subjects (cf. FDP_ITT.1)
- S.RAM_UNIT: RAM addressable unit, with security attribute "rights: (TA identifier/REE) ->(Read/Write/ReadWrite/NoAccess). For instance, an addressable unit may be allocated or have its access rights changed upon TA instance creation or when sharing memory references between a client (CA, TA) and a TA. Notes: 1) A RAM_UNIT typically stands for a byte in the C language; 2) there is no RAM access restriction applicable to the TEE itself
- S.COMM_AGENT: proxy between CAs in the REE and the TEE and its TAs.

Objects stand for passive entities inside the TOE:

- OB.TA_STORAGE (user data): Trusted Storage space of a TA, with security attributes "owner" (TA identifier), "inExtMem" (True/False) and "TEE_identity" (TEE identifier).

- OB.SRT (TSF data): the TEE Storage Root of Trust, with security attribute "TEE_identity" (TEE identifier).

Cryptographic objects are a special kind of TEE objects:

- OB.TA_KEY (user data): (handle to a) user key (persistent or transient), with security attributes "usage", "owner" (TA identifier), "isExtractable" (True/False).

Information stands for data exchanged between subjects:

- I.RUNTIME_DATA (user data or TSF Data depending on the owner): data belonging to the TA or to the TEE itself. Stands for parameter values, return values, content of memory regions in cleartext. Note: Data that is encrypted and authenticated is not considered I.RUNTIME_DATA.

TSF data consists of runtime TSF data and TSF persistent data (also called TEE persistent data) necessary to provide the security services. It includes all the security attributes of users, subjects, objects and information.

Cryptographic operations on user keys performed by S.API on behalf of TA_INSTANCE:

- OP.USE_KEY: any cryptographic operation that uses a key
- OP.EXTRACT_KEY: any operation that populates a key.

Trusted Storage operations performed by S.API on behalf of TA_INSTANCE:

- OP.LOAD: any operation used to get back persistent objects (data and keys) to be used by the TA
- OP.STORE: any operation used to store persistent objects (data and keys). It stands for object creation, object deletion, object renaming, object truncation and write to an object.

Other operations:

- Any operation executed by the TEE on behalf of a TA_INSTANCE.

This ST defines the following access control and information flow security functional policies (SFP):

Runtime Data Information Flow Control SFP:

- Purpose: To control the flow of runtime data from and to executable entities and memory. This policy contributes to ensure the integrity and confidentiality of runtime data
- Subjects: S.TA_INSTANCE, S.TA_INSTANCE_SESSION, S.API, S.COMM_AGENT, S.RESOURCE, S.RAM_UNIT
- Information: I.RUNTIME_DATA
- Security attributes: S.RESOURCE.state, S.RAM_UNIT.rights and S.API.caller
- SFR instances: FDP_IFC.2/Runtime, FDP_IFF.1/Runtime, FDP_ITT.1/Runtime.

TA Keys Access Control SFP:

- Purpose: To control the access to TA keys, which is granted to the TA that owns the key only.This policy contributes to the confidentiality of TA keys.
- Subjects: S.API, S.TA_INSTANCE and any other subject in the TEE
- Objects: OB.TA_KEY

- Security attributes: OB.TA_KEY.usage, OB.TA_KEY.owner, OB.TA_KEY.isExtractable, and S.API.caller
- Operations: OP.USE_KEY, OP.EXTRACT_KEY
- SFR instances: FDP_ACC.1/TA_Keys, FDP_ACF.1/TA_keys, FMT_MSA.1/TA_keys, FMT_MSA.3/TA_keys, FMT_SMF.1.

Trusted Storage Access Control SFP:

- Purpose: To control the access to TA storage where persistent TA data and keys are stored, which is granted on behalf of the owner TA only. This policy also enforces the binding of TA trusted storage to the TEE storage root of trust OB.SRT
- Subjects: S.API
- Objects: OB.TA_STORAGE, OB.SRT
- Security attributes: S.API.caller, OB.TA_STORAGE.owner, OB.TA_STORAGE.inExtMem, OB.TA_STORAGE.TEE_identity and OB.SRT.TEE_identity
- Operations: OP.LOAD, OP.STORE
- SFR intances: FDP_ACC.1/Trusted Storage, FDP_ACF.1/Trusted Storage, FDP_ROL.1/Trusted Storage, FMT_MSA.1/Trusted Storage, FMT_MSA.3/Trusted Storage, FMT_SMF.1.

5.2.1.1 Identification

FIA_ATD.1 User attribute definition

FIA_ATD.1.1 The TSF shall maintain the following list of security attributes belonging to individual users: *CA_identity, TA_identity, TA_properties*.

Application Note:

The lifespan of the attributes in such a list is the following:

• CA_identity: The lifetime of this attribute is that of the lifetime of the client session to the TA

• TA_identity: The availability of this attribute is that of the availability of the TA to clients, limited further by the TAs presence in the system

• TA_properties: The lifetime of this attribute is that of the availability of the TA to clients, limited further by the TAs presence in the system.

FIA_UID.2 User identification before any action

FIA_UID.2.1 The TSF shall require each user to be successfully identified before allowing any other TSF-mediated actions on behalf of that user.

Application Note:

User stands for Client Application or Trusted Application.

FIA_USB.1 User-subject binding

FIA_USB.1.1 The TSF shall associate the following user security attributes with subjects acting on the behalf of that user:

o Client (CA or TA) identity is codified into the client_identity of the requested TA session

FIA_USB.1.2 The TSF shall enforce the following rules on the initial association of user security attributes with subjects acting on the behalf of users:

o If the client is a TA, then the client_identity must be equal to the TA_identity of the TA subject that is the client

o *If the client is a CA，then the client identity must indicate the CA client.*

FIA_USB.1.3 The TSF shall enforce the following rules governing changes to the user security attributes associated with subjects acting on the behalf of users:

o No modification of client_identity is allowed after initialization

Application Note:

The TOE Internal API defines the codification rules of the CA identity.

FMT_SMR.1 Security roles

FMT_SMR.1.1 The TSF shall maintain the roles

o TSF

o TA_User

FMT_SMR.1.2 The TSF shall be able to associate users with roles.

Application Note:

The TA_User role is the TSF running on behalf of a TA, upon request from the REE (by Client Applications) or from other TAs.

5.2.1.2 Confidentiality, Integrity and Isolation

FDP_IFC.2/Runtime Complete information flow control

FDP_IFC.2.1/Runtime The TSF shall enforce the *Runtime Data Information Flow Control SFP* on

o Subjects: S.TA_INSTANCE, S.TA_INSTANCE_SESSION, S.API, S.COMM_AGENT, S.RESOURCE, S.RAM_UNIT

o Information: I.RUNTIME_DATA

and all operations that cause that information to flow to and from subjects covered by the SFP.

FDP_IFC.2.2/Runtime The TSF shall ensure that all operations that cause any information in the TOE to flow to and from any subject in the TOE are covered by an information flow control SFP.

Application Note:

The flow control policy specifies the conditions to communicate runtime data from one

subject to another. It applies to operations that are standard interfaces of these subjects.

FDP_IFF.1/Runtime Simple security attributes

FDP_IFF.1.1/Runtime The TSF shall enforce the *Runtime Data Information Flow Control SFP* based on the following types of subject and information security attributes: *S.RESOURCE.state, S.RAM_UNIT.rights and S.API.caller*.

FDP_IFF.1.2/Runtime The TSF shall permit an information flow between a controlled subject and controlled information via a controlled operation if the following rules hold:

o Rules for information flow between S.TA_INSTANCE and S.RAM_UNIT:

- *Flow of I.RUNTIME_DATA from S.TA_INSTANCE to S.RAM_UNIT is allowed only if S.RAM_UNIT.rights(S.TA_INSTANCE) is Write or ReadWrite*
- *Flow of I.RUNTIME_DATA from S.RAM_UNIT to S.TA_INSTANCE is allowed only if S.RAM_UNIT.rights(S.TA_INSTANCE) is Read or ReadWrite*

o Rules for information flow from and to S.COMM_AGENT:

- *Flow of I.RUNTIME_DATA from S.COMM_AGENT to S.RAM_UNIT is allowed only if S.RAM_UNIT.rights(REE) is Write or ReadWrite*
- *Flow of I.RUNTIME_DATA from S.RAM_UNIT to S.COMM_AGENT is allowed only if S.RAM_UNIT.rights(REE) is Read or ReadWrite*

o Rules for information flow from and to S.API:

- *Flow of I.RUNTIME_DATA from S.API to S.RAM_UNIT is allowed only if S.RAM_UNIT.rights(S.API.caller) is Write or ReadWrite*
- *Flow of I.RUNTIME_DATA from S.RAM_UNIT to S.API is allowed only if S.RAM_UNIT.rights(S.API.caller) is Read or ReadWrite*

o Rules for information flow from and to S.RESOURCE:

- *Flow of I.RUNTIME_DATA between S.API and S.RESOURCE is allowed only if the resource is under TEE control (S.RESOURCE.state = TEE).*

FDP_IFF.1.3/Runtime The TSF shall enforce the *none*.

FDP_IFF.1.4/Runtime The TSF shall explicitly authorise an information flow based on the following rules:

o Rules for information flow from and to S.TA_INSTANCE_SESSION:

- *Flow of I.RUNTIME_DATA that are parameter or return values is allowed between S.TA_INSTANCE_SESSION and S.COMM_AGENT*
- *Flow of I.RUNTIME_DATA that are parameter or return values is allowed between S.TA_INSTANCE_SESSION and S.API.*

FDP_IFF.1.5/Runtime The TSF shall explicitly deny an information flow based on the following rules: *Any information flow involving a TEE subject unless one of the conditions stated in FDP_IFF.1.1/1.2/1.3/1.4 holds.*

Application Note:

The access rights configuration managed by S.RAM_UNIT shall ensure that RAM

addressable units used to TSF data are appropriately protected (in integrity for TEE firmware, in integrity and confidentiality for TEE runtime data)

FDP_RIP.1/Runtime Subset residual information protection

FDP_RIP.1.1/Runtime The TSF shall ensure that any previous information content of a resource is made unavailable upon the deallocation of the resource from the following objects: *TEE and TA runtime objects*.

Application Note:

This operation applies in particular upon:

o Failure detection (cf. FPT_FLS.1)

o TA instance and TA session closing.

5.2.1.3 Cryptography

FCS_COP.1 Cryptographic operation

FCS_COP.1.1 The TSF shall perform *operation list in Table 6* in accordance with a specified cryptographic algorithm *algorithm list in Table 6* and cryptographic key sizes *key sizes list in Table 6* that meet the following standards: *standards listed in Table 6*.

Application Note:

The Security Target shall provide in this SFR cryptographic operations used within the TOE for:

o verifying the authenticity of TA code

o protecting the consistency and confidentiality of Trusted Storage data. These operations are based on the TEE storage root of trust key.

FCS_CKM.1 Cryptographic key generation

FCS_CKM.1.1 The TSF shall generate cryptographic keys in accordance with a specified cryptographic key generation algorithm *algorithm list in Table 6* and specified cryptographic key sizes *key sizes list in Table 6* that meet the following: *standards listed in Table 6*.

FCS_CKM.4 Cryptographic key destruction

FCS_CKM.4.1 The TSF shall destroy cryptographic keys in accordance with a specified cryptographic key destruction method *overwriting of the key value* that meets the following: *overwriting with a constant pattern*.

FDP_ACC.1/TA_keys Subset access control

FDP_ACC.1.1/TA_keys The TSF shall enforce the *TA Keys Access Control SFP* on

o Subjects: S.API, S.TA_INSTANCE and any other subject in the TEE

o Objects: OB.TA_KEY

o Operations: OP.USE_KEY, OP.EXTRACT_KEY.

FDP_ACF.1/TA_keys Security attribute based access control

FDP_ACF.1.1/TA_keys The TSF shall enforce the *TA Keys Access Control SFP* to objects based on the following: *OB.TA_KEY.usage, OB.TA_KEY.owner, OB_TA_KEY.isExtractable and S.API.caller.*

FDP_ACF.1.2/TA_keys The TSF shall enforce the following rules to determine if an operation among controlled subjects and controlled objects is allowed:

o OP.USE_KEY is allowed if the following conditions hold:

- *The TA instance that requested the operation to the API owns the key (S.API.caller = OB.TA_KEY.owner)*
- *The intended usage of the key (OB.TA_KEY.usage) matches the requested Operation*

o OP.EXTRACT_KEY is allowed if the following conditions hold:

- *The TA instance that requested the operation to the API owns the key (S.API.caller = OB.TA_KEY.owner)*
- *The operation attempts to extract the public part of OB.TA_KEY or the key is extractable (OB.TA_KEY.isExtractable = True).*

FDP_ACF.1.3/TA_keys The TSF shall explicitly authorise access of subjects to objects based on the following additional rules: *none*.

FDP_ACF.1.4/TA_keys The TSF shall explicitly deny access of subjects to objects based on the following additional rules:

o Any access to a user key attempted directly from S.TA_INSTANCE or any other subject of the TEE that is not S.API

o Any access to a user key attempted from S.API without valid caller (S.API.caller is undefined)

Application Note:

This requirement states access conditions to keys through the TEE Internal API only: OP.USE_KEY and OP.EXTRACT_KEY stand for operations of the API.

FDP_ACF.1.3/TA_keys: Note that ownership in the current TEE internal API specification is limited to each TA having access to all, and only to, its own objects.

FMT_MSA.1/TA_keys Management of security attributes

FMT_MSA.1.1/TA_keys The TSF shall enforce the *TA Keys Access Control SFP* to restrict the ability to change_default, query and modify the security attributes *OB.TA_KEY.usage, OB.TA_KEYS.isExtractable and OB.TA_KEY.owner* to *the following roles:*

o change_default, query and modify OB.TA_KEY.usage to TA_User role

o query OB.TA_KEY.owner to the TSF role.

FMT_MSA.3/TA_keys Static attribute initialisation

FMT_MSA.3.1/TA_keys The TSF shall enforce the *TA Keys Access Control SFP* to provide restrictive default values for security attributes that are used to enforce the SFP.

FMT_MSA.3.2/TA_keys The TSF shall allow the *TA_User role* to specify alternative initial values to override the default values when an object or information is created.

5.2.1.4 Initialization, Operation and Firmware Integrity

FAU_ARP.1 Security alarms

FAU_ARP.1.1 The TSF shall take [assignment: list of actions] upon detection of a potential security violation.

Refinement:

The TSF shall take the following actions upon detection of a potential security violation:

o detection of consistency violation of TA data, TA code or TEE data: reject the error or malicious data.

Application Note:

The TOE implement several security enhancement such as Code segment Read Only, Data segment Never eXecute, Stack Canary, CFI, ASLR etc. to detect the consistency violation of TA data, TA code or TEE data. When the TOE detect potential security violation, TSF will enter secure state, stop the module running where failure occurred.

Detection of TEE firmware integrity will be done in fastboot which is not part of the TOE.

FDP_SDI.2 Stored data integrity monitoring and action

FDP_SDI.2.1 The TSF shall monitor user data stored in containers controlled by the TSF for [assignment: integrity errors] on all objects, based on the following attributes: [assignment: user data attributes].

Refinement:

The TSF shall monitor TEE runtime data, TEE persistent data, TA data and keys and TA code stored in containers controlled by the TSF for authenticity and consistency errors on all objects, based on the following attributes: TEE runtime data, TEE persistent data, TA data and keys and TA code.

FDP_SDI.2.2 Upon detection of a data integrity error, the TSF shall [assignment: action that does not depend on the compromised data].

Refinement:

o Upon detection of authenticity or consistency errors in TEE runtime data or TEE persistent data, the TSF shall stop the execution of the TSF and return an error

o Upon detection of TA code authenticity or consistency errors, the TSF shall abort the execution of the TA instance

o Upon detection of TA data or TA keys authenticity or consistency errors, the TSF shall

- **Not give back any compromised data**

Application Note:

This SFR applies to TEE runtime data in volatile memory (this data is not stored in non-volatile memory) and to TEE persistent data, TA data and keys and TA code in both volatile and non-volatile memory.

This SFR is used for both TSF and user data as similar mechanisms are involved to protect the consistency of this data.

FPT_FLS.1 Failure with preservation of secure state

FPT_FLS.1.1 The TSF shall preserve a secure state when the following types of failures occur:

o Device binding failure

o Cryptographic operation failure

o Invalid CA requests, in particular bad-formed requests

o Panic states

o TA code, TA data or TA keys authenticity or consistency failure

o TEE data (in particular TA properties, TEE keys and all security attributes) authenticity or consistency failure

o TEE initialization failure

o Unexpected commands in the current TEE state

Application Note:

Device binding failure occurs when (part of) the stored data has not been bound by the same TEE.

If everything goes well since TOE start, the TOE works in normal state. When failure occurred, the TOE stop the failure module running so that the TOE will not leak any sensitive information like encryption key, key structure data to REE world.

FMT_SMF.1 Specification of Management Functions

FMT_SMF.1.1 The TSF shall be capable of performing the following management functions:

o Management of TA keys security attributes

o Provision of Trusted Storage security attributes to authorised users.

FPT_TEE.1 Testing of external entities

FPT_TEE.1.1 The TSF shall run a suite of tests *prior execution* to check the fulfillment of *authenticity of TA code*.

FPT_TEE.1.2 If the test fails, the TSF shall *not start the execution of the TA instance*.

5.2.1.5 TEE Identification

FAU_SAR.1 Audit review

FAU_SAR.1.1 The TSF shall provide *all users* with the capability to read *TEE identifier* from the audit records.

FAU_SAR.1.2 The TSF shall provide the audit records in a manner suitable for the user to interpret the information.

FAU_STG.1 Protected audit trail storage

FAU_STG.1.1 The TSF shall protect the stored audit records in the audit trail from unauthorized deletion.

FAU_STG.1.2 The TSF shall be able to prevent unauthorised modifications to the stored audit records in the audit trail.

Application Note:

The TEE identifier is generated on-TEE, and the generating algorithm is defined by the manufacture who will guarantee the TEE identifier to be unique.

When the TOE startup,TOE will read DIEID and HUK from Efuse,and generate the TEE identifier based on that two parameters.The TEE identifier is stored in TEE's volatile memory,and will be lost when TOE shutdown.

This identifier shall not be modified during the end-usage phase.

5.2.1.6 Trusted Storage

FDP_ACC.1/Trusted Storage Subset access control

FDP_ACC.1.1/Trusted Storage The TSF shall enforce the *Trusted Storage Access Control SFP* on

o Subjects: S.API

o Objects: OB.TA_STORAGE, OB.SRT

o Operations: OP.LOAD, OP.STORE.

FDP_ACF.1/Trusted Storage Security attribute based access control

FDP_ACF.1.1/Trusted Storage The TSF shall enforce the *Trusted Storage Access Control SFP* to objects based on the following: *S.API.caller, OB.TA_STORAGE.owner, OB.TA_STORAGE.inExtMem, OB.TA_STORAGE.TEE_identity and OB.SRT.TEE_identity.*

FDP_ACF.1.2/Trusted Storage The TSF shall enforce the following rules to determine if an operation among controlled subjects and controlled objects is allowed:

o OP.LOAD of an object from OB.TA_STORAGE is allowed if the following conditions hold:

- *The operation is performed by S.API*

- *The load request comes from an instance of the owner of the trusted storage space (S.API.caller = OB.TA_STORAGE.owner)*
- *OB.TA_STORAGE is bound to the TEE storage root of trust OB.SRT (OB.TA_STORAGE.TEE_identity = OB.SRT.TEE_identity)*
- *If OB.TA_STORAGE is located in external memory accessible to the REE (OB.TA_STORAGE.inExtMem = True) then the object is authenticated and decrypted before load*

o OP.STORE of an object to OB.TA_STORAGE is allowed if the following conditions hold:

- *The operation is performed by S.API*
- *The store request comes from an instance of the owner of the trusted storage space (S.API.caller = OB.TA_STORAGE.owner)*
- *OB.TA_STORAGE is bound to the TEE storage root of trust OB.SRT (OB.TA_STORAGE.TEE_identity = OB.SRT.TEE_identity)*
- *If OB.TA_STORAGE is located in external memory accessible to the REE (OB.TA_STORAGE.inExtMem = True) then the object is signed and encrypted before storage.*

FDP_ACF.1.3/Trusted Storage The TSF shall explicitly authorise access of subjects to objects based on the following additional rules: *none.*

FDP_ACF.1.4/Trusted Storage The TSF shall explicitly deny access of subjects to objects based on the following additional rules:

o Any access to a trusted storage attempted from S.API without valid caller (S.API.caller = undefined)

o Any access to a trusted storage that was bound to a different TEE (OB.TA_STORAGE.TEE_identity different from OB.SRT.TEE_identity)

o Any access to a trusted storage from a subject different from S.API

FDP_ROL.1/Trusted Storage Basic rollback

FDP_ROL.1.1/Trusted Storage The TSF shall enforce *Trusted Storage Access Control SFP* to permit the rollback of the *unsuccessful or interrupted OP.STORE operation* on the *storage*.

FDP_ROL.1.2/Trusted Storage The TSF shall permit operations to be rolled back within the *store operation failed.*

Application Note:

This SFR enforces atomicity of any write operation [IAPI].

FMT_MSA.1/Trusted Storage Management of security attributes

FMT_MSA.1.1/Trusted Storage The TSF shall enforce the *Trusted Storage Access Control SFP* to restrict the ability to query the security attributes *OB.TA_STORAGE.owner, OB.TA_STORAGE.inExtMem, OB.TA_STORAGE.TEE_identity and OB.SRT.TEE_identity to TA_User role*.

FMT_MSA.3/Trusted Storage Static attribute initialisation

FMT_MSA.3.1/Trusted Storage The TSF shall enforce the *Trusted Storage Access Control SFP* to provide restrictive default values for security attributes that are used to enforce the SFP.

FMT_MSA.3.2/Trusted Storage The TSF shall allow the TA_User to specify alternative initial values to override the default values when an object or information is created.

FDP_ITT.1/Trusted Storage Basic internal transfer protection

FDP_ITT.1.1/Trusted Storage The TSF shall enforce the *Trusted Storage Access Control SFP* to prevent the disclosure and modification of user data when it is transmitted between physically-separated parts of the TOE.

5.3 Security Functional Requirements Rationale

5.3.1 Security Objectives for the TOE

O.CA_TA_IDENTIFICATION The following requirements contribute to fulfill the objective:

o FIA_ATD.1 enforces the management of the Client and TA identity and properties as security attributes, which then become TSF data, protected in integrity and confidentiality

o FIA_UID.2 requires the identification of Client application or TA before any action, thus allowing the access to services and data to authorized users only

o FIA_USB.1 enforces the association of the user identity to the active entity that acts on behalf of the user and to check that this is a valid identity.

O.KEYS_USAGE The following requirements contribute to fulfill the objective:

o FCS_COP.1 allows to specify the cryptographic operations in the scope of the evaluation if any

o FDP_ACC.1/TA_keys, FDP_ACF.1/TA_keys, FMT_MSA.1/TA_keys, FMT_MSA.3/TA_keys, FMT_SMR.1 and FMT_SMF.1 state the key access policy, which grants access to the owner of the key only.

OE.TEE_ID The following requirements contribute to fulfill the objective:

o FAU_SAR.1 enforces TEE identifier access capabilities

o FAU_STG.1 enforces TEE identifier storage capabilities

O.INITIALIZATION The following requirements contribute to fulfill the objective:

o FPT_FLS.1 states that the TEE has to reach a secure state upon initialization or device binding failure

O.OPERATION The following requirements contribute to fulfill the objective:

o FAU_ARP.1 states the TEE responses to potential security violations

o FDP_SDI.2 enforces the monitoring of consistency and authenticity of TEE data and TA, and it states the behavior in case of failure

o FIA_ATD.1, FIA_UID.2 and FIA_USB.1 ensure that actions are performed by identified users

o FMT_SMR.1 states the two operational roles enforced by the TEE

o FPT_FLS.1 states that abnormal operations have to lead to a secure state

o FDP_ACC.1/Trusted Storage, FDP_ACF.1/Trusted Storage, FMT_MSA.1/Trusted Storage, FMT_MSA.3/Trusted Storage and FMT_SMF.1 state the policy for controlling access to TA storage

o FDP_IFC.2/Runtime and FDP_IFF.1/Runtime state the policy for controlling access to TA and TEE execution spaces

o FDP_ACC.1/TA_keys, FDP_ACF.1/TA_keys, FMT_MSA.1/TA_keys, FMT_MSA.3/TA_keys and FMT_SMF.1 state the key access policy.

O.RUNTIME_CONFIDENTIALITY The following requirements contribute to fulfill the objective:

o FDP_IFC.2/Runtime and FDP_IFF.1/Runtime ensure read access to authorized entities only

o FDP_RIP.1/Runtime states resource clean up policy.

O.RUNTIME_INTEGRITY The following requirements contribute to fulfill the objective:

o FDP_IFC.2/Runtime and FDP_IFF.1/Runtime state TEE and TA runtime data policy, which grants write access to authorized entities only

o FDP_SDI.2 monitors the authenticity and consistency of TEE code, the TEE runtime data, the TA code and the TA data and keys and states the response upon failure.

O.TA_AUTHENTICITY The following requirements contribute to fulfill the objective:

o FDP_SDI.2 enforces the consistency and authenticity of TA code during storage

o FPT_TEE.1 enforces the check of authenticity of TA code prior execution

o FCS_COP.1 states the cryptography used to verify the authenticity of TA code

O.TA_ISOLATION The following requirements contribute to fulfill the objective:

o FDP_ACC.1/Trusted Storage, FDP_ACF.1/Trusted Storage, FMT_MSA.1/Trusted Storage, FMT_MSA.3/Trusted Storage and FMT_SMF.1 state the policy for controlling access to TA storage

o FCS_COP.1 state the cryptographic algorithms used for Trusted Storage to ensure confidentiality and authenticity of TA data

o FDP_IFC.2/Runtime and FDP_IFF.1/Runtime state the policy for controlling access to TA execution space

o FPT_FLS.1 enforces TA isolation by maintaining a secure state, in particular in case of panic states.

O.TEE_DATA_PROTECTION The following requirements contribute to fulfill the objective:

o FCS_COP.1 states the cryptography used to protect consistency and confidentiality of the TEE data in external memory, if applicable

o FDP_SDI.2 monitors the authenticity and consistency of TEE persistent data and states the response upon failure

O.TEE_ISOLATION The following requirements contribute to fulfill the objective:

o FDP_IFC.2/Runtime and FDP_IFF.1/Runtime state the policy for controlling access to TEE execution space.

O.TRUSTED_STORAGE The following requirements contribute to fulfill the objective:

o FCS_COP.1 states the cryptography used to protect integrity and confidentiality of the TA data in external memory, if applicable

o FDP_ACC.1/Trusted Storage, FDP_ACF.1/Trusted Storage, FDP_ROL.1/Trusted Storage, FMT_MSA.1/Trusted Storage, FMT_MSA.3/Trusted Storage and FMT_SMF.1 state Storage state the policy for accessing TA trusted storage and protecting the confidentiality of data

o FDP_SDI.2 enforces the consistency and authenticity of the trusted storage

o FDP_ITT.1/Trusted Storage ensure protection against disclosure of TEE and TA data that is transferred between resources

o FPT_FLS.1 maintains a secure state.

5.3.2 Rationale tables of Security Objectives and SFRs

Security Objectives	Security Functional Requirements	Rationale
O.CA_TA_IDENTIFICATION	FIA_ATD.1, FIA_UID.2, FIA_USB.1	Section 5.3.1
O.KEYS_USAGE	FDP_ACC.1/TA_keys, FDP_ACF.1/TA_keys, FMT_MSA.1/TA_keys, FMT_MSA.3/TA_keys, FMT_SMF.1, FCS_COP.1, FMT_SMR.1, FCS_CKM.1, FCS_CKM.4	Section 5.3.1
OE.TEE_ID	FAU_SAR.1, FAU_STG.1	Section 5.3.1
O.INITIALIZATION	FPT_FLS.1	Section 5.3.1
O.OPERATION	FAU_ARP.1, FDP_SDI.2, FIA_ATD.1, FIA_UID.2, FIA_USB.1, FMT_SMR.1, FPT_FLS.1, FDP_IFC.2/Runtime, FDP_IFF.1/Runtime, FMT_SMF.1, FDP_ACC.1/Trusted Storage, FDP_ACF.1/Trusted Storage, FMT_MSA.1/Trusted Storage, FMT_MSA.3/Trusted Storage, FDP_ACC.1/TA_keys, FDP_ACF.1/TA_keys, FMT_MSA.1/TA_keys, FMT_MSA.3/TA_keys,	Section 5.3.1
O.RUNTIME_CONFIDENTIALITY	FDP_IFC.2/Runtime, FDP_IFF.1/Runtime, FDP_RIP.1/Runtime,	Section 5.3.1
O.RUNTIME_INTEGRITY	FDP_IFC.2/Runtime, FDP_IFF.1/Runtime, FDP_SDI.2	Section 5.3.1
O.TA_AUTHENTICITY	FDP_SDI.2, FCS_COP.1, FPT_TEE.1, FCS_CKM.1, FCS_CKM.4	Section 5.3.1

O.TA_ISOLATION	FDP_ACC.1/Trusted Storage, FDP_ACF.1/Trusted Storage, FDP_IFC.2/Runtime, FDP_IFF.1/Runtime, FMT_MSA.1/Trusted Storage, FMT_MSA.3/Trusted Storage, FMT_SMF.1, FCS_COP.1, FPT_FLS.1, FCS_CKM.1, FCS_CKM.4	Section 5.3.1
O.TEE_DATA_PROTECTION	FDP_SDI.2, FCS_COP.1, FCS_CKM.1, FCS_CKM.4	Section 5.3.1
O.TEE_ISOLATION	FDP_IFC.2/Runtime, FDP_IFF.1/Runtime	Section 5.3.1
O.TRUSTED_STORAGE	FDP_ACC.1/Trusted Storage, FDP_ACF.1/Trusted Storage, FDP_ROL.1/Trusted Storage, FDP_SDI.2, FMT_MSA.1/Trusted Storage, FMT_MSA.3/Trusted Storage, FCS_COP.1, FMT_SMF.1, FPT_FLS.1, FDP_ITT.1/Trusted Storage, FCS_CKM.1, FCS_CKM.4	Section 5.3.1

Table 15: Security Objectives and SFRs - Coverage

Security Functional Requirements	Objectives
FIA_ATD.1	O.CA_TA_IDENTIFICATION, O.OPERATION
FIA_UID.2	O.CA_TA_IDENTIFICATION, O.OPERATION
FIA_USB.1	O.CA_TA_IDENTIFICATION, O.OPERATION
FMT_SMR.1	O.KEYS_USAGE, O.OPERATION
FDP_IFC.2/Runtime	O.OPERATION, O.RUNTIME_CONFIDENTIALITY, O.RUNTIME_INTEGRITY, O.TA_ISOLATION, O.TEE_ISOLATION
FDP_IFF.1/Runtime	O.OPERATION, O.RUNTIME_CONFIDENTIALITY, O.RUNTIME_INTEGRITY, O.TA_ISOLATION, O.TEE_ISOLATION
FDP_RIP.1/Runtime	O.RUNTIME_CONFIDENTIALITY
FCS_COP.1, FCS_CKM.1, FCS_CKM.4	O.KEYS_USAGE, O.TA_AUTHENTICITY, O.TA_ISOLATION, O.TEE_DATA_PROTECTION, O.TRUSTED_STORAGE
FDP_ACC.1/TA_keys	O.KEYS_USAGE, O.OPERATION
FDP_ACF.1/TA_keys	O.KEYS_USAGE, O.OPERATION
FMT_MSA.1/TA_keys	O.KEYS_USAGE, O.OPERATION
FMT_MSA.3/TA_keys	O.KEYS_USAGE, O.OPERATION
FAU_ARP.1	O.OPERATION
FDP_SDI.2	O.OPERATION, O.RUNTIME_INTEGRITY, O.TA_AUTHENTICITY, O.TEE_DATA_PROTECTION, O.TRUSTED_STORAGE
FPT_FLS.1	O.INITIALIZATION, O.OPERATION, O.TA_ISOLATION, O.TRUSTED_STORAGE
FMT_SMF.1	O.KEYS_USAGE, O.OPERATION, O.TA_ISOLATION, O.TRUSTED_STORAGE
FPT_TEE.1	O.TA_AUTHENTICITY
FAU_SAR.1	OE.TEE_ID

FAU_STG.1	OE.TEE_ID
FDP_ACC.1/Trusted Storage	O.OPERATION, O.TA_ISOLATION, O.TRUSTED_STORAGE
FDP_ACF.1/Trusted Storage	O.OPERATION, O.TA_ISOLATION, O.TRUSTED_STORAGE
FDP_ROL.1/Trusted Storage	O.TRUSTED_STORAGE
FMT_MSA.1/Trusted Storage	O.OPERATION, O.TA_ISOLATION, O.TRUSTED_STORAGE
FMT_MSA.3/Trusted Storage	O.OPERATION, O.TA_ISOLATION, O.TRUSTED_STORAGE
FDP_ITT.1/Trusted Storage	O.TRUSTED_STORAGE

Table 16: SFRs and Security Objectives

5.3.3 Dependencies

SFRs	**CC Dependencies**	**Satisfied Dependencies**
FIA_ATD.1	No Dependencies	
FIA_UID.2	No Dependencies	
FIA_USB.1	(FIA_ATD.1)	FIA_ATD.1
FMT_SMR.1	(FIA_UID.1)	FIA_UID.2
FDP_IFC.2/Runtime	(FDP_IFF.1)	FDP_IFF.1/Runtime
FDP_IFF.1/Runtime	(FDP_IFC.1) and (FMT_MSA.3)	FDP_IFC.2/Runtime
FDP_RIP.1/Runtime	No Dependencies	
FCS_CKM.1	(FCS_CKM.2 or FCS_COP.1) and (FCS_CKM.4)	FCS_CKM.4, FCS_COP.1
FCS_CKM.4	(FCS_CKM.1 or FDP_ITC.1 or FDP_ITC.2)	FCS_CKM.1
FCS_COP.1	(FCS_CKM.1 or FDP_ITC.1 or FDP_ITC.2) and (FCS_CKM.4)	FCS_CKM.1, FCS_CKM.4
FDP_ACC.1/TA_keys	(FDP_ACF.1)	FDP_ACF.1/TA_keys
FDP_ACF.1/TA_keys	(FDP_ACC.1) and (FMT_MSA.3)	FDP_ACC.1/TA_keys, FMT_MSA.3/TA_keys
FMT_MSA.1/TA_keys	(FDP_ACC.1 or FDP_IFC.1) and (FMT_SMF.1) and (FMT_SMR.1)	FMT_SMR.1, FDP_ACC.1/TA_keys, FMT_SMF.1
FMT_MSA.3/TA_keys	(FMT_MSA.1) and (FMT_SMR.1)	FMT_SMR.1, FMT_MSA.1/TA_keys
FAU_ARP.1	(FAU_SAA.1)	
FDP_SDI.2	No Dependencies	
FPT_FLS.1	No Dependencies	
FMT_SMF.1	No Dependencies	
FPT_TEE.1	No Dependencies	
FAU_SAR.1	No Dependencies	
FAU_STG.1	No Dependencies	

FDP_ACC.1/Trusted Storage	(FDP_ACF.1)	FDP_ACF.1/Trusted Storage
FDP_ACF.1/Trusted Storage	(FDP_ACC.1) and (FMT_MSA.3)	FDP_ACC.1/Trusted Storage, FMT_MSA.3/Trusted storage
FDP_ROL.1/Trusted Storage	(FDP_ACC.1 or FDP_IFC.1)	FDP_ACC.1/Trusted storage
FMT_MSA.1/Trusted Storage	(FDP_ACC.1 or FDP_IFC.1) and (FMT_SMF.1) and (FMT_SMR.1)	FMT_SMR.1, FMT_SMF.1, FDP_ACC.1/Trusted Storage
FMT_MSA.3/Trusted Storage	(FMT_MSA.1) and (FMT_SMR.1)	FMT_SMR.1, FMT_MSA.1/Trusted Storage
FDP_ITT.1/Trusted Storage	(FDP_ACC.1 or FDP_IFC.1)	FDP_ACC.1/Trusted storage

Table 17: SFRs Dependencies

5.3.4 Rationale for the exclusion of Dependencies

The dependency FMT_MSA.3 of FDP_IFF.1/Runtime is discarded. There is no management of security attributes by authorized users for this information flow control SFP as all security attributes are exclusively managed by the TSF, therefore the dependency FMT_MSA.3 is not applicable.

The dependency FAU_SAA.1 of FAU_ARP.1 is discarded. The potential security violations are explicitly defined in the FAU_ARP.1 requirement. There is no audited event defined in the SFR of this ST.

The dependency FAU_GEN.1 of FAU_SAR.1 is discarded. This dependency is discarded as the only audit record considered is the TEE identifier and this identifier is set before TOE delivery and non-modifiable afterwards.

The dependency FAU_GEN.1 of FAU_STG.1 is discarded. This dependency is discarded as the only audit record considered is the TEE identifier and this identifier is set before TOE delivery and non-modifiable afterwards.

5.4 Security Assurance Requirements

This ST follows a set of Security Assurance Requirements (SARs) which provided by [TEE PP] for the TOE, it consists of the EAL 2 package augmented with the extended AVA_TEE.2 SAR. This SAR raises the AVA_VAN.2 Basic attack potential to a TEE-Low attack potential.

5.5 Security Assurance Requirements Rationale

The Evaluation Assurance Level 2 has been chosen to commensurate with the threat environment that is experienced by typical consumers of the TOE.

The assurance level defined in this ST consists of the predefined assurance package EAL 2 with the augmentation AVA_TEE.2 (extended SAR TEE Vulnerability analysis) in order to reach the TEE-Low attack potential.

This augmented EAL permits a developer to gain sufficient assurance from positive security engineering based on good TEE commercial development practices that are compatible with industry constraints, in

particular the life cycle of TEE and TEE-enabled devices. The developer has to provide evidence of security engineering at design, testing, guidance, configuration management and delivery levels as required by standard EAL 2. In order to cope with the high exposure of the TEE and the interest that TEE-enabled devices and their embedded services may represent to attackers, the product has to show resistance to TEE-Low attack potential. This attack potential matches the threat analysis performed on typical architectures and attack profiles in the field.

The components AVA_VAN.2 and AVA_TEE.2 are chosen together in the augmented EAL package, while they should normally be exclusive. The reason of this choice is to perform the attack quotation according to the two tables and to allow EAL 2 product recognition for the schemes that do not recognize the AVA_TEE.2 component.

6 TOE Summary Specification

6.1 TOE Security Functional Specification

For every security function a short identifier is specified in brackets to allow direct referencing to single items in other documents.

6.1.1 Protection of TSF

The TOE provides several security mechanism to ensure TOE's self security. Detailed functions include:

o The TOE can run internal TA and external TA. Both internal and external TAs are encrypted and signature by Huawei, and will be decrypted and check the signature before loading into the TOE. The TOE will stop loading TA if tampering detected.

o The TOE will enter a secure state when some key operation error occurred, to protect the TOE's data from leaking out.

o The TOE will stop the TSF execution if an integrity error of the TEE runtime data or the TEE persistent data is detected.

(FPT_TEE.1, FPT_FLS.1, FDP_SDI.2, FMT_SMF.1, FMT_SMR.1)

6.1.2 Trusted Storage

The TOE provides trusted storage service for its security functions. The trust storage resides in Trusted core framework. TAs running is TEE can load or store its owning files through Trusted Storage service, but any intention to access other TA's file will be prevented.

o The trusted storage service is the only task that have the permission to access the file in Trusted Storage. The TOE will reject any request to access trusted file from other tasks.

o The trusted storage service in TOE will receive trusted file access request from other TA, if the request is illegal or the TA has no permission to access the trusted file, the request will be denied.

o The trusted storage service will encrypt the data before write the data into the trusted file, and the encrypted key is binding to the request TA. Different TA use different key. The trusted storage service will decrypt the data and send back to the reading request TA.

o If the file write operation failed, The TOE will detect the failure and rollback to previous state.

(FDP_ACC.1/Trusted storage, FDP_ACF.1/Trusted Storage, FDP_ROL.1/Trusted Storage, FMT_MSA.1/Trusted Storage, FMT_MSA.3/Trusted Storage, FDP_ITT.1/Trusted Storage, FMT_SMF.1)

6.1.3 Cryptographic Support

The TOE provides cryptographic operations to support TOE's security functions such as CA Authentication, TA signature verification, communication encryption, trust storage etc. The TOE provides software cryptographic operations.

O The TOE provide a series of cryptographic operations such as hash calculation, HMAC calculation, signature generation, encryption and decryption in accordance with the cryptographic algorithms specified in Table 6.

O The TOE provide TA_Keys in accordance with GP Internal API Specification [IAPI], including management of keys security attributes. The TOE provides generation of keys according to the algorithms defined in Table 6 and key destruction by overwriting the key value with zeros.

(FCS_COP.1, FDP_ACC.1/TA_Keys, FDP_ACF.1/TA_keys, FMT_MSA.1/TA_keys, FMT_MSA.3/TA_keys, FCS_CKM.1, FCS_CKM.4, FMT_SMF.1)

6.1.4 User Identification and Authentication

The TSF will identify and authenticate CA according to white-CA-list of TA, and identify and authenticate TA by its signature, any further actions performing by CA/TA user must be prevent before successful authentication. Both identifiers of CA and TA cannot be modified during their life cycle.

(FIA_ATD.1, FIA_UID.2, FIA_USB.1)

6.1.5 Security Audit

The TOE will detect potential security violation such as violation of TA data, TA code or TEE data, and generate audit log. The TOE will send the log info from TEE to REE, which can be read by human with tool.

Every audit log record of TOE contains TEE identifier which is generated on-TEE. The users can retrieve the TEE identifier from the TOE through a proprietary API.

Audit log records are only accessible to the root user, so they are protected from unauthorized deletion and modification.

(FAU_ARP.1, FAU_SAR.1, FAU_STG.1)

6.1.6 Protection of TA

When load TA, the TSF will check the signature of it so that integrity and authenticity are ensured.

For each loaded TA, the TSF will create an isolate running environment, any reading or writing accesses from other TAs are forbidden. And TSF will monitor the authenticity and consistency of TA code, data and keys, when a failure is occurred, the TSF will cleanup all those data and the TA will exit.

(FDP_IFC.2/Runtime, FDP_IFF.1/Runtime, FDP_RIP.1/Runtime, FDP_SDI.2)

6.1.7 Communication Data Protection between CA and TA

The CA user must complete identity authentication before performing any further actions, and it can only communicate with the specified TA which is pre-defined in the TOE.

The TSF encrypts the key data of the communication to prevent data sniffing from the REE world, adds token info to prevent data replay attack from the REE world, and uses checksum to prevent data modification.

(FDP_IFC.2/Runtime, FDP_IFF.1/Runtime,FDP_RIP.1/Runtime)

7 Abbreviations, Terminology and References

7.1 Abbreviations

AES	Advanced Encryption Standard (defined in [AES])
CA	Client Application
CC	Common Criteria
CEM	Common Evaluation Methodology
CM	Configuration Management
DES	Data Encryption Standard
DRM	Digital Rights Management
EAL	Evaluation Assurance Level
IPC	Inter-Process Communication
NFC	Near Field Communication
OS	Operating System
OSP	Organisational Security Policy
PCB	Printed Circuit Board
PP	Protection Profile
RAM	Random Access Memory
REE	Rich Execution Environment
RFC	Request For Comments
ROM	Read Only Memory
RSA	Rivest / Shamir / Adleman asymmetric algorithm
SAR	Security Assurance Requirement
SE	Secure Element
SFR	Security Functional Requirement
SFP	Security Function Policy
SFR	Security Functional Requirement
SHA	Secure Hash Algorithm
SoC	System-on-Chip
SPD	Security Problem Definition

ST	Security Target
TA	Trusted Application
TEE	Trusted Execution Environment
TOE	Target of Evaluation
TSF	TOE Security Functions
TSFI	TSF Interface
TSS	TOE Summary Specification
TUI	Trusted User Interface

7.2 Terminology

This section contains definitions of technical terms that are used with a meaning specific to this document. Terms defined in the [CC] are not reiterated here, unless stated otherwise.

Term	Definition
Application Programming Interface (API)	A set of rules that software programs can follow to communicate with each other.
Client Application (CA)	An application running outside of the Trusted Execution Environment (TEE) making use of the TEE Client API that accesses facilities provided by the Trusted Applications inside the TEE. Contrast Trusted Application.
Consistency	A property of the TEE persistent storage that stands at the same time for runtime and startup consistency. Runtime consistency stands for the guarantee that the following clauses hold: • Read/Read: Two successful readings from the same storage location give the same value if the TEE did not write to this location and the TEE was not reset in between • Write/Read: A successful reading from a given storage location gives the value that the TEE last wrote to this location if the TEE was not reset in between. Startup consistency stands for the guarantee that the following clause holds: • During a given power cycle, the stored data used at startup is the data for which runtime consistency was enforced on the same TEE on a previous power cycle. Consistency implies runtime integrity of what is uccessfully written and read back – values or code. However the stored data used at startup may be restored from an old power cycle, not the latest one. It is still consistent at start-up because it corresponds to a memory snapshot at a given time, but it represents an integrity loss compared with the latest power cycle. This notion is weaker than integrity that must be preserved between power cycles.
Device binding	Device binding is the property of data being only usable on a unique given system instance, here a TEE.
Execution	A set of hardware and software components that provide facilities (computing, memory management, input/out, etc.)

Environment (EE)	necessary to support applications.
Monotonicity	Monotonicity is the property of a variable whose value is either always increasing or always decreasing over time.
Power cycle	A power cycle is the lapse between the moment a device is turned on and the moment the device is turned off afterwards.
Production TEE	A TEE residing in a device that is in the end user phase of its life cycle.
REE Communication Agent	An REE Rich OS driver that enables communication between the REE and the TEE. Contrast TEE Communication Agent.
Rich Execution Environment (REE)	An environment that is provided and governed by a Rich OS, potentially in conjunction with other supporting operating systems and hypervisors; it is outside of the TEE. This environment and applications running on it are considered un-trusted. Contrast Trusted Execution Environment.
Rich OS	Typically an OS providing a much wider variety of features than that of the OS running inside the TEE. It may be very open in its ability to accept applications. It will have been developed with functionality and performance as key goals, rather than security. Due to the size and needs of the Rich OS it will run in an execution environment that may be larger than the TEE hardware (often called an REE – Rich Execution Environment) with much lower physical security boundaries. From the TEE viewpoint, everything in the REE has to be considered un-trusted, though from the Rich OS point of view there may be internal trust structures. Contrast Trusted OS.
Root of Trust (RoT)	Generally the smallest distinguishable set of hardware, firmware,and/or software that must be inherently trusted and which is closely tied to the logic and environment on which it performs its trusted actions.
System-on-Chip (SoC)	An electronic system all of whose components are included in a single integrated circuit.
TA instance time / TA persistent time	Time value available to a Trusted Application through the TEE Internal API. The API offers two types of time values: System Time, which exists only during runtime, and Persistent time, which persists over resets. System Time must be monotonic for a given TA instance, and the returned value is called “TA instance time”. Persistent time depends only on the TA but not on a particular instance, it must be monotonic even across power cycles. Its monotonicity across power cycles is related to the Time and Rollback optional PP-module.
TEE Client API	The software interface used by clients running in the REE to communicate with the TEE and with the Trusted Applications executed by the TEE.
TEE Communication Agent	A TEE Trusted OS driver that enables communication between REE and TEE. Contrast REE Communication Agent.
TEE Internal API	The software interface exposing TEE functionality to Trusted Applications.
TEE Service Library	A software library that includes all security related drivers.
Trusted Application (TA)	An application running inside the Trusted Execution Environment that exports security related functionality to Client Applications outside of the TEE.

	Contrast Client Application.
Trusted Execution Environment (TEE)	An execution environment that runs alongside but isolated from an REE. A TEE has security capabilities and meets certain securityrelated requirements: It protects TEE assets from general software attacks, defines rigid safeguards as to data and functions that a program can access, and resists a set of defined threats. There are multiple technologies that can be used to implement a TEE, and the level of security achieved varies accordingly. For more information, see OMTP ATE TR1 [OMTP-TR1]. Contrast Rich Execution Environment.
Trusted OS	The operating system running in the TEE. It has been designed primarily to enable the TEE using security-based design techniques. It provides the GlobalPlatform TEE Internal API to Trusted Applications and a proprietary method to enable the GlobalPlatform TEE Client API software interface from other EE. Contrast Rich OS.
Trusted Storage	In GlobalPlatform TEE documents, trusted storage indicates storage that is protected to at least the robustness level defined for OMTP Secure Storage (in section 5 of [OMTP-TR1]). It is protected either by the hardware of the TEE, or cryptographically by keys held in the TEE. If keys are used they are at least of the strength used to instantiate the TEE. A GlobalPlatform TEE Trusted Storage is not considered hardware tamper resistant to the levels achieved by Secure Elements.

7.3 References

[CC1]	Common Criteria for Information Technology Security Evaluation, Part 1: Introduction and general model. Version 3.1. Revision 5. April 2017. CCMB-2017-04-001.
[CC2]	Common Criteria for Information Technology Security Evaluation, Part 2: Security functional requirements. Version 3.1. Revision 5. April 2017. CCMB-2017-04-002.
[CC3]	Common Criteria for Information Technology Security Evaluation, Part 3: Security assurance requirements. Version 3.1. Revision 5. April 2017. CCMB-2017-04-003.
[TEE PP]	GlobalPlatform Device Committee - TEE Protection Profile Version 1.2.1, Public Release November 2016, Document Reference: GPD_SPE_021
[CEM]	Common Methodology for Information Technology Security Evaluation, Evaluation Methodology. Version 3.1, revision 5, April 2017. CCMB-2017-04-004.
[PPMOD]	CC and CEM addenda, Modular PP, Version 1.0, March 2014. CCDB-2014-03-001
[APSC]	Application of Attack Potential to Smartcards. Version 2.9 January 2013. Joint Interpretation Library.
[OMTPTR1]	Open Mobile Terminal Platform Advanced Trusted Environment OMTP TR1 v1.1
[OMTPST]	OMTP Security Threats on Embedded Consumer Devices v1.1
[WP]	The Trusted Execution Environment: Delivering Enhanced Security at a Lower Cost to the Mobile Market, GlobalPlatform White paper, Feb

	2011
[SA]	TEE System Architecture, GlobalPlatform (Last applicable version)
[IAPI]	TEE Internal API Specification, GlobalPlatform (Last applicable version)
[CAPI]	TEE Client API Specification, GlobalPlatform (Last applicable version)[CAPI]
[AES]	ADVANCED ENCRYPTION STANDARD (AES). FIPS PUB 197.November 2011.
[DES]	DATA ENCRYPTION STANDARD (DES). FIPS PUB 46-3. October 1999.
[RSA]	RSA Laboratories Publication RSA Cryptographic Standard. PCKS#1 v2.2. October 2012
[JTAG]	SECURE HASH STANDARD. FIPS PUB 180-4. March 2012 [SHA] IEEE Standard IEEE 1149.1-2001 Standard Test Access Port and Boundary-Scan Architecture http://standards.ieee.org/reading/ieee/std_public/description/testtech/1149.1-2001_desc.html
[RFC2119]	Key words for use in RFCs to Indicate Requirement Levels

END