Realm Management Extension (RME) Support in TF-A

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Agenda

- Brief introduction to Arm CCA
  - Realm Management Extension (RME)
- TF-A changes for RME

Introduction to Arm CCA & RME

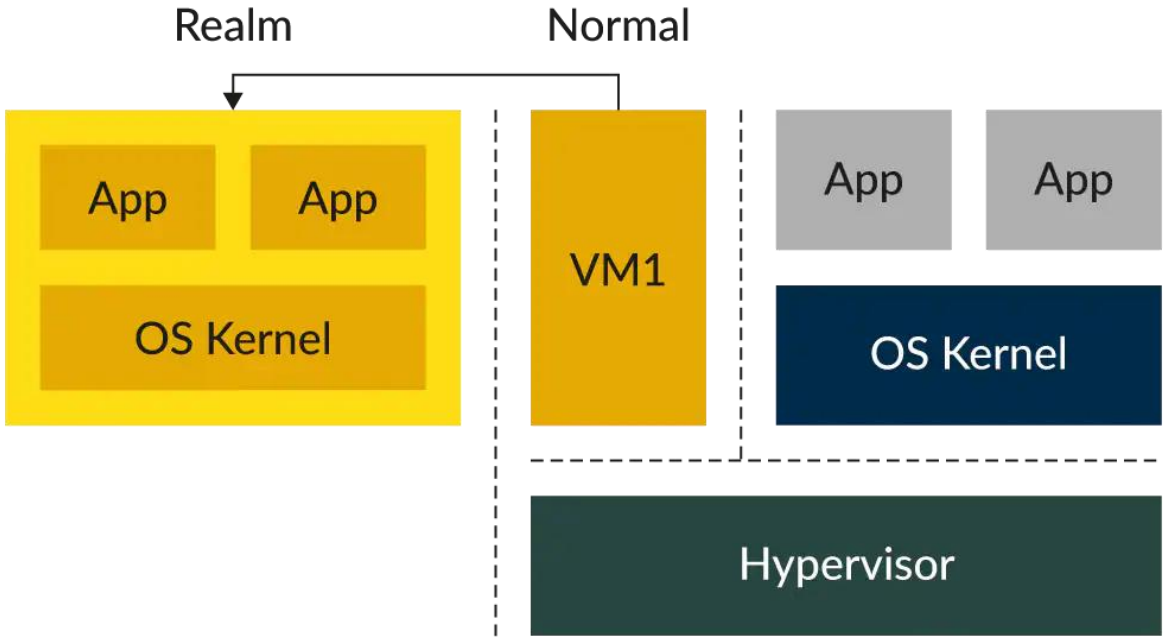
Arm Confidential Compute Architecture (CCA)

- Provides hardware-backed secure execution environments called **Realms**

- Code and data in realms is shielded from observation or modification by privileged software and hardware agents (Hypervisor, Host OS, TrustZone)

- Realms are supported at the VM level
  - Hypervisor manages Realm VM resources (scheduling, memory) but can not access those resources

- The platform and realms are attestable



https://www.arm.com/why-arm/architecture/security-features/arm-confidential-compute-architecture

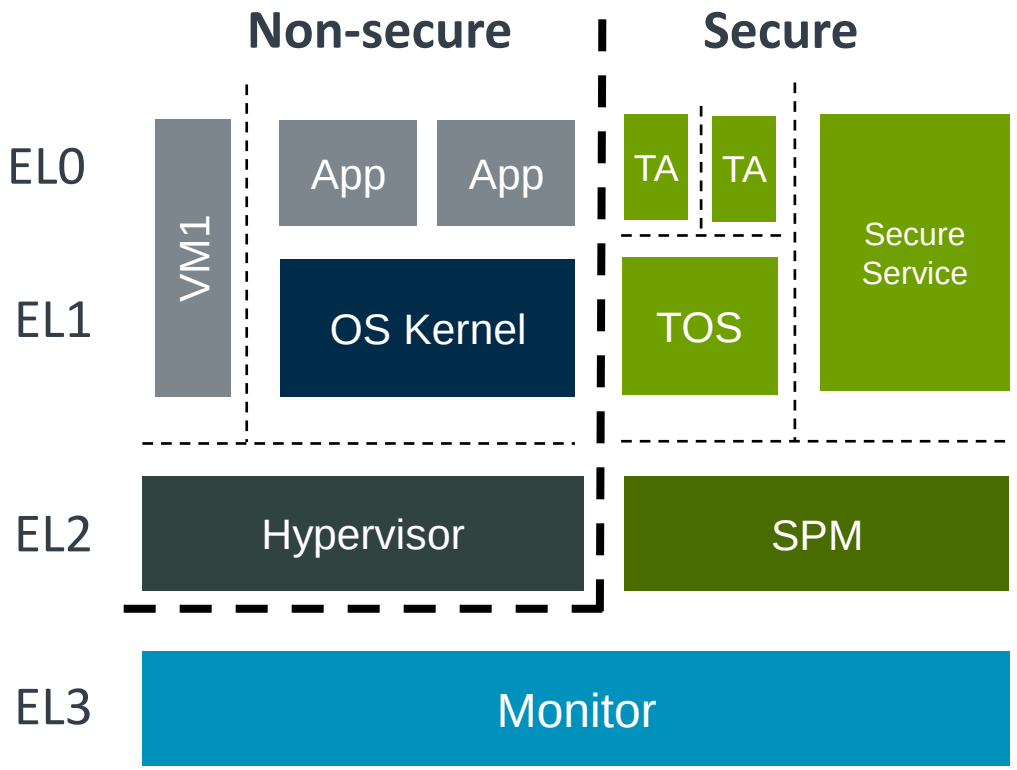
Arm CCA – TrustZone recap

- Two Physical Address Spaces (PAS) and security states: **Secure & Non-secure**
- Isolation boundary is based on security state

Security State	Non-secure PAS	Secure PAS
Non-secure	Yes	No
Secure	Yes	Yes

Physical memory access rules

- No architectural mechanism to dynamically move memory /devices between Secure and Non-Secure PAS
  - Memory for Secure PA is typically statically carved out



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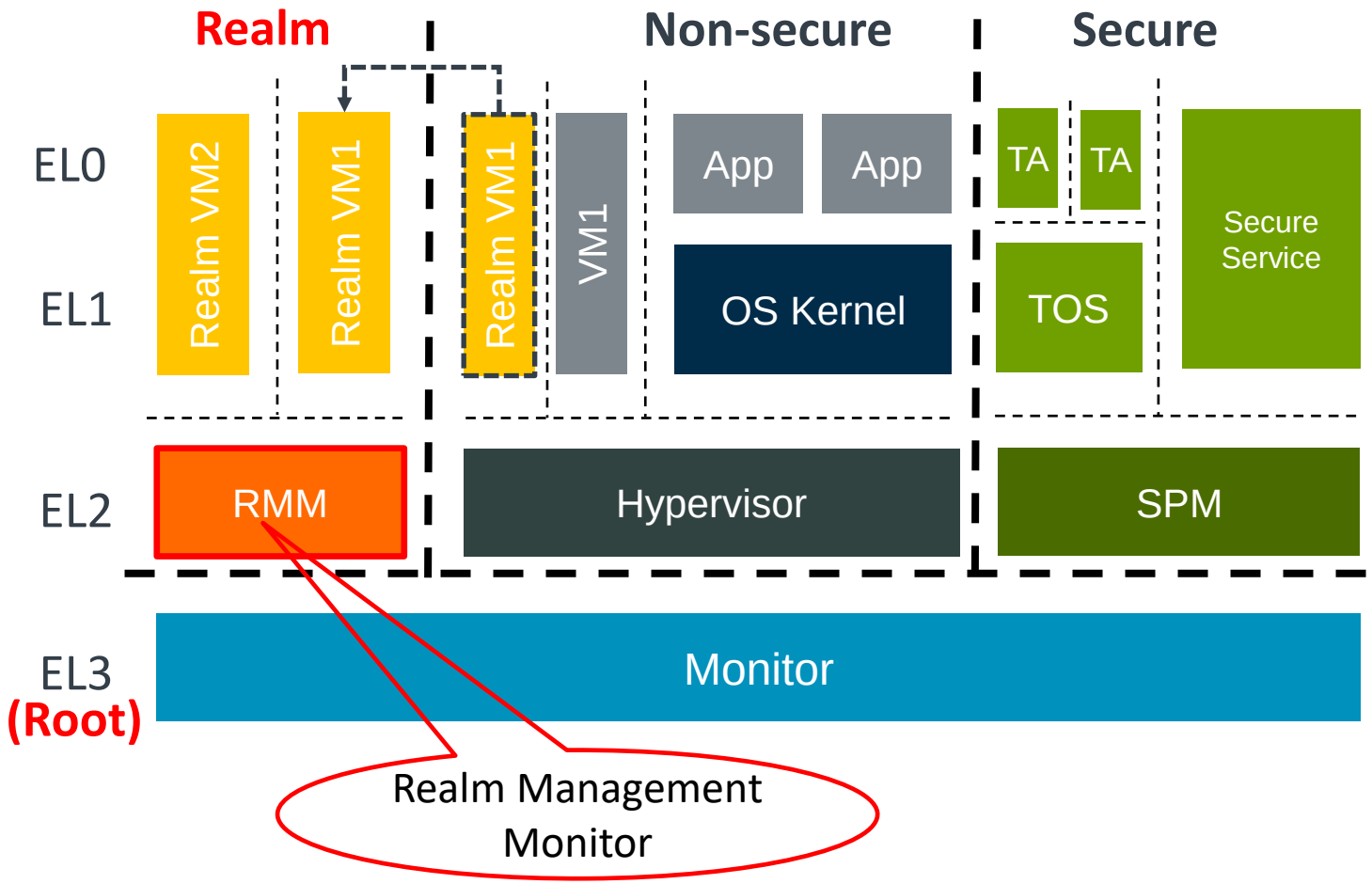
Arm CCA – Realm Management Extension (RME)

- Adds two new PAS and security states: **Root & Realm**
- Secure and Realm are mutually distrusting

Security State	Non-secure PAS	Secure PAS	Realm PAS	Root PAS
Non-secure	Yes	No	No	No
Secure	Yes	Yes	No	No
Realm	Yes	No	Yes	No
Root	Yes	Yes	Yes	Yes

Physical memory access rules



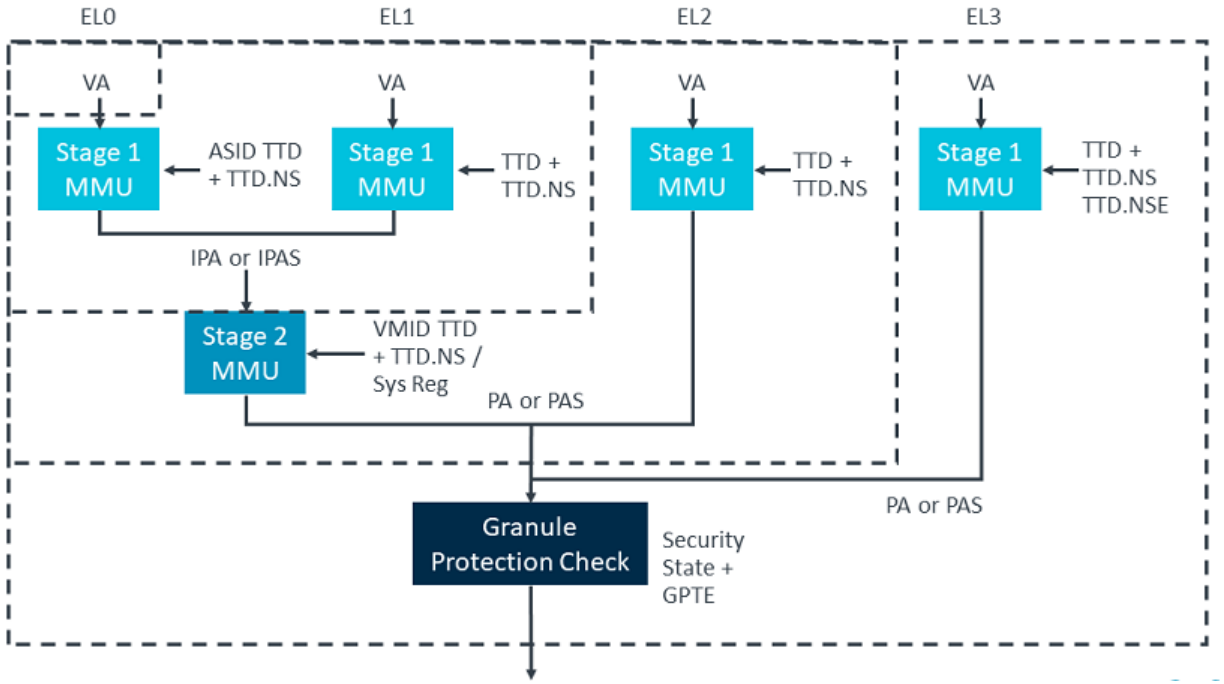
Arm CCA – Realm Management Extension (RME)

- Physical memory access control enforced by HW **Granule Protection Check (GPC)** by MMU

- PAS assignment of every granule (page) of physical memory is described in a **Granule Protection Table (GPT)**
  - GPT is controlled by the monitor in EL3

- Memory can move between physical address spaces dynamically

  (Memory delegation/undelegation)

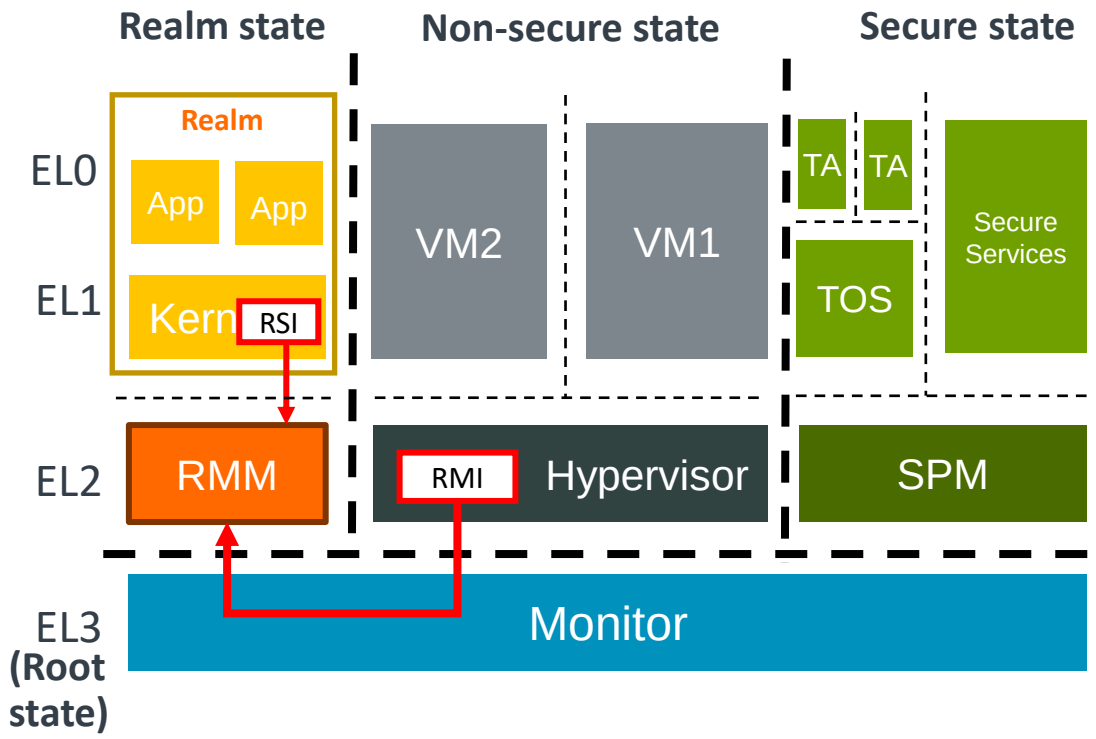


https://developer.arm.com/documentation/den0125/latest/Arm-CCA-Hardware-Architecture

Arm CCA – Realm Management Monitor (RMM)

- Realm world firmware used to manage the execution of Realm VMs and their interaction with the hypervisor

- Two interfaces:
  - **Realm Management Interface (RMI)** with the Non-secure host
    - Used by host hypervisor to request management control from the RMM (creation, population, execution, and destruction of the realms)
  - **Realm Service Interface (RSI)** with Realm VMs
    - Channel to provide services to Realms such as cryptographic services and attestation
    - channel for memory management requests



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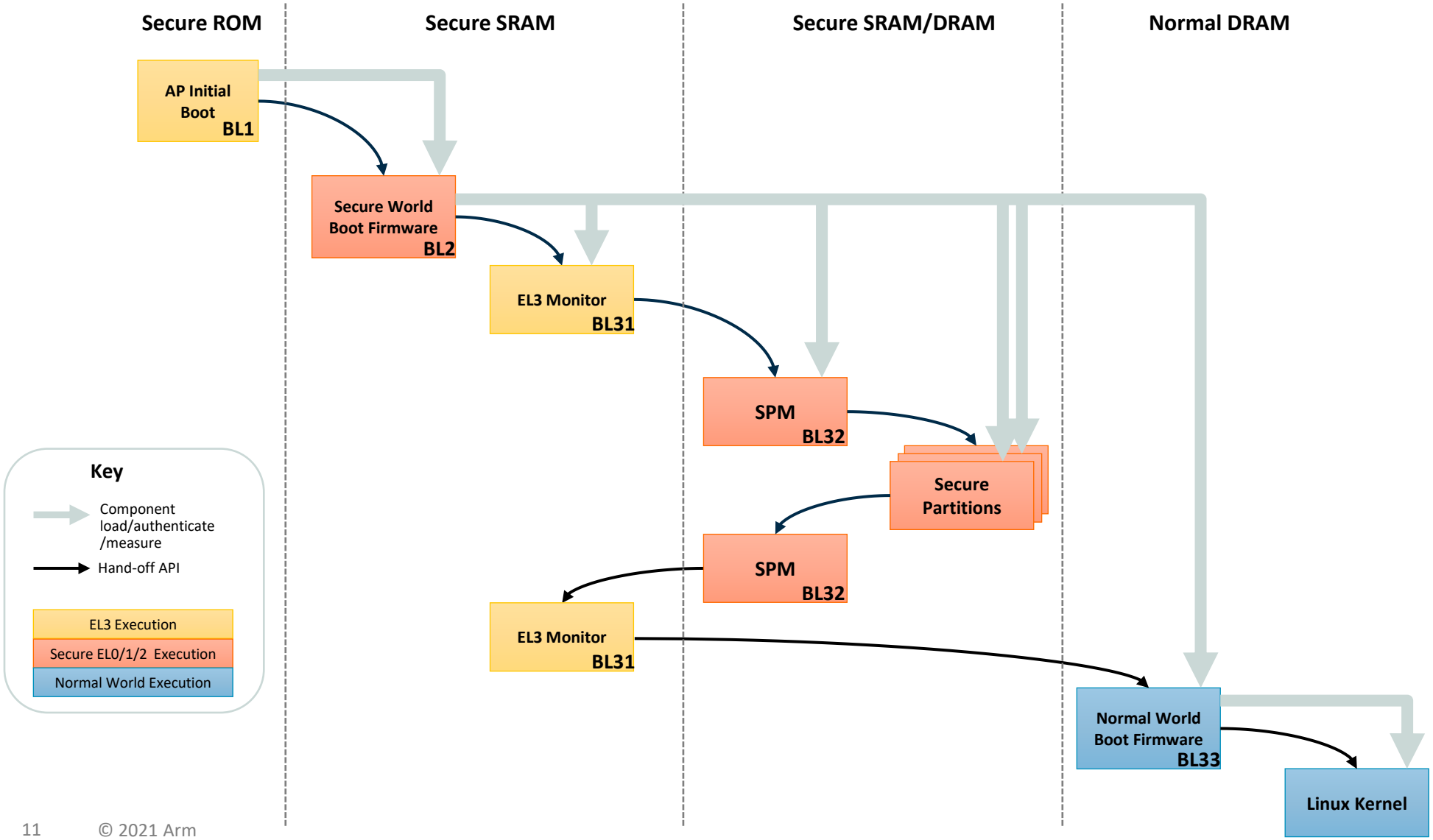
TF-A Changes for RME

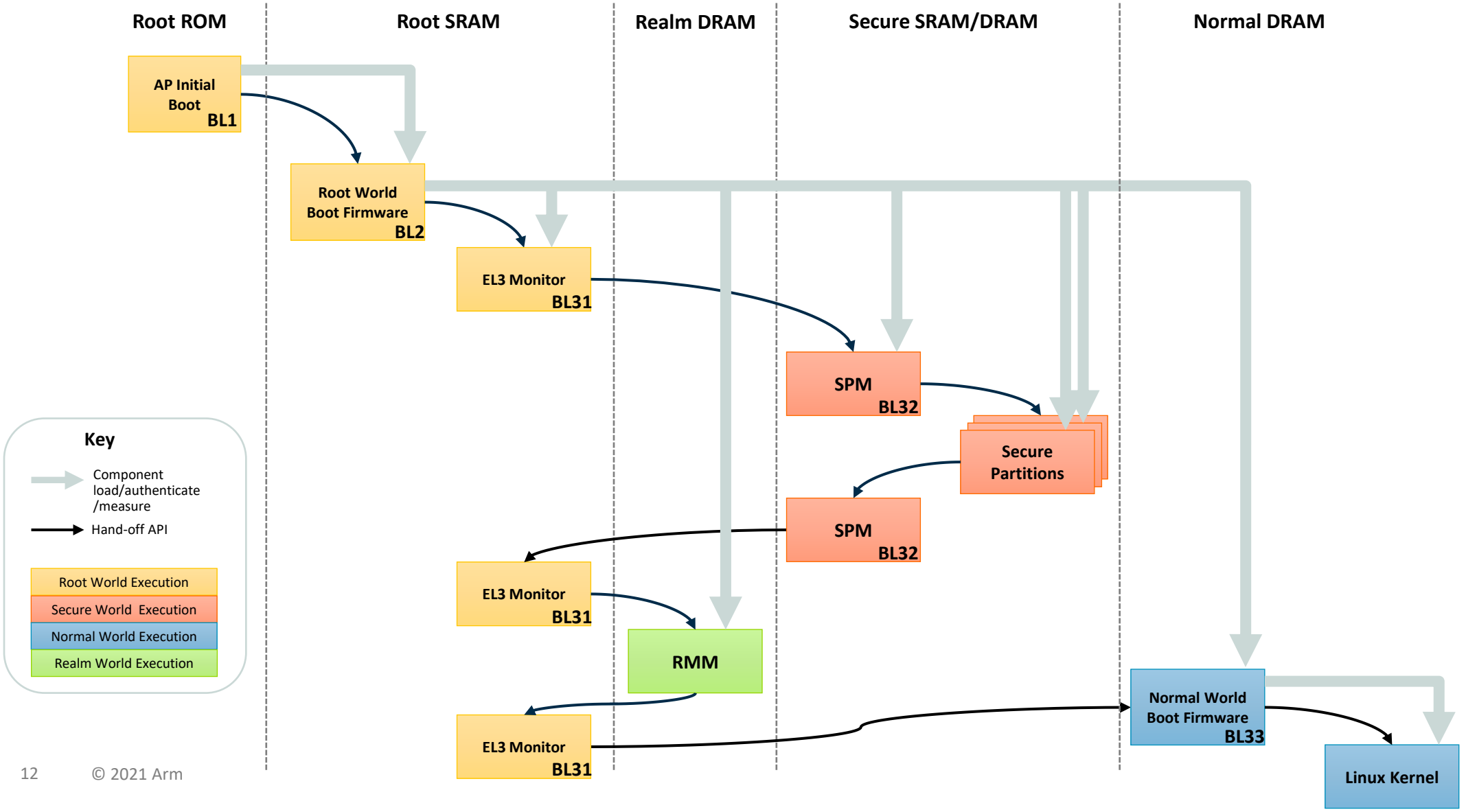
EL3 firmware (TF-A) responsibilities

- Loading and running RMM firmware
- Switching between Normal, Secure and Realm worlds
- Management of GPT

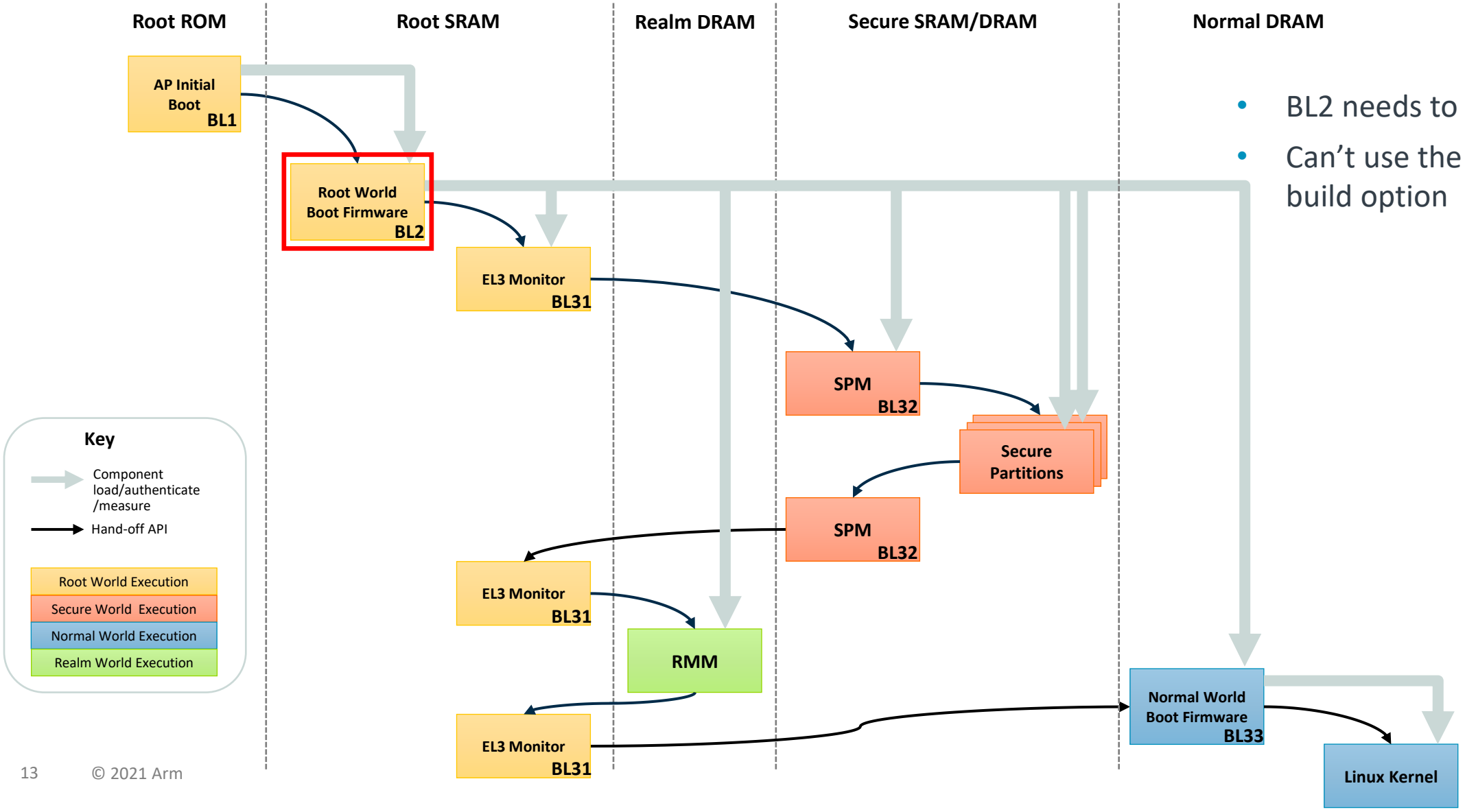
Boot flow changes – Typical boot flow with SPM



Boot flow changes – New boot flow with RMM

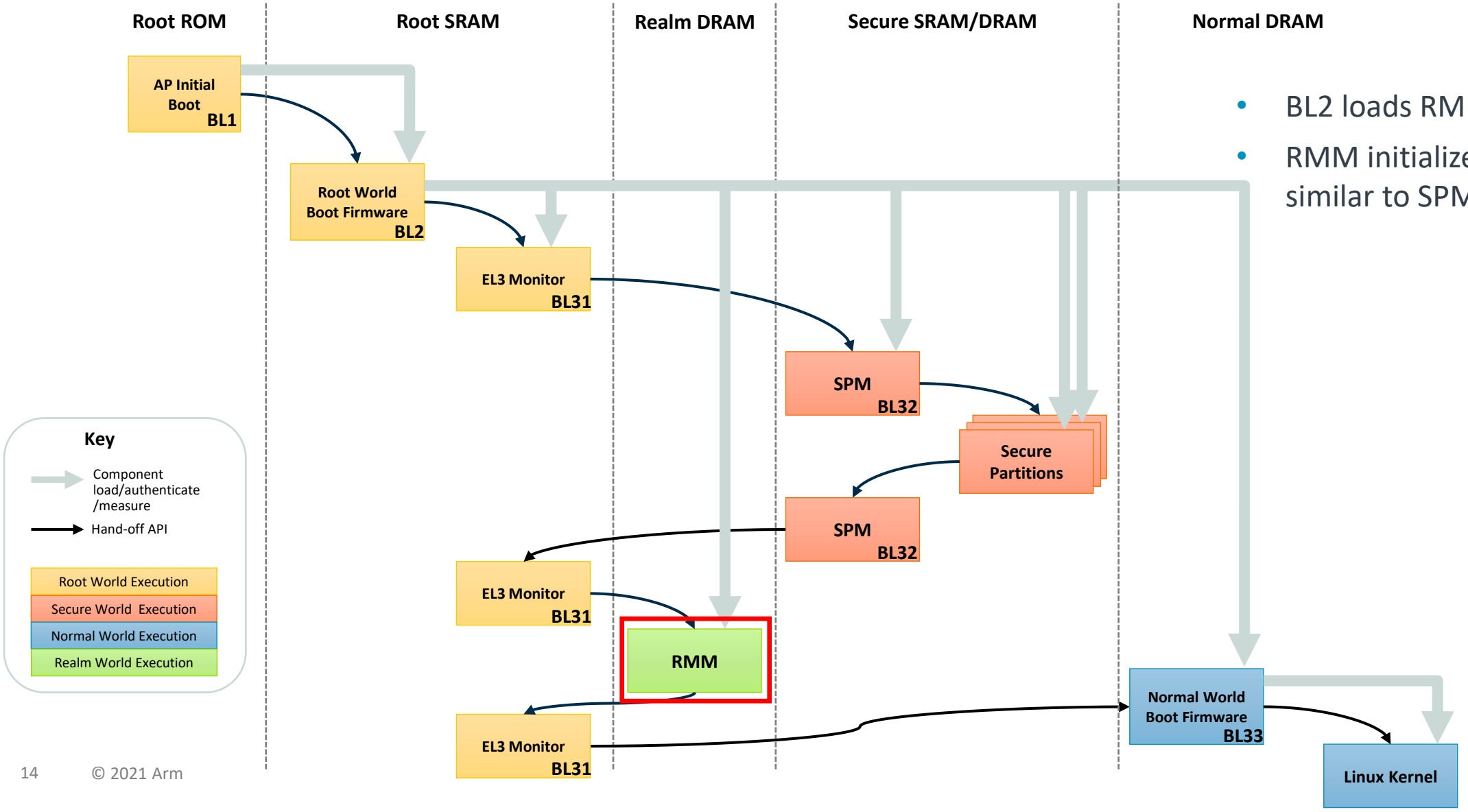


Boot flow changes – New boot flow with RMM



- BL2 needs to run at EL3 (Root)
- Can't use the *BL2_AT_EL3* build option

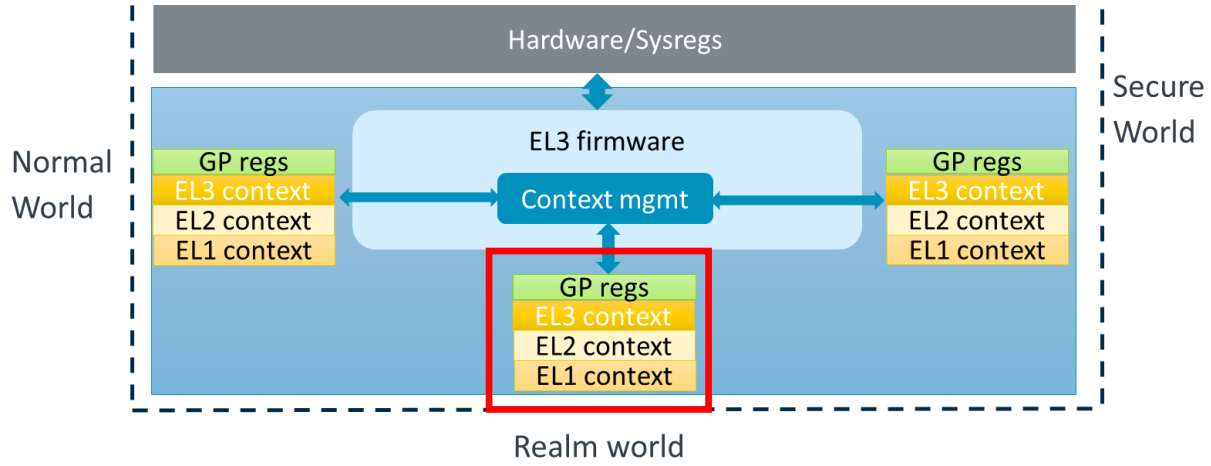
Boot flow changes – New boot flow with RMM



- BL2 loads RMM
- RMM initialized by BL31, similar to SPM

TF-A Changes – Enhancements

- Context management changes
  - New CPU context for Realm world
- Translation library changes
  - Enhanced v2 xlat table library to include Root and Realm world attributes
- Support for RMM image
  - Support for RMM image in fiptool
- New build option, *ENABLE_RME*

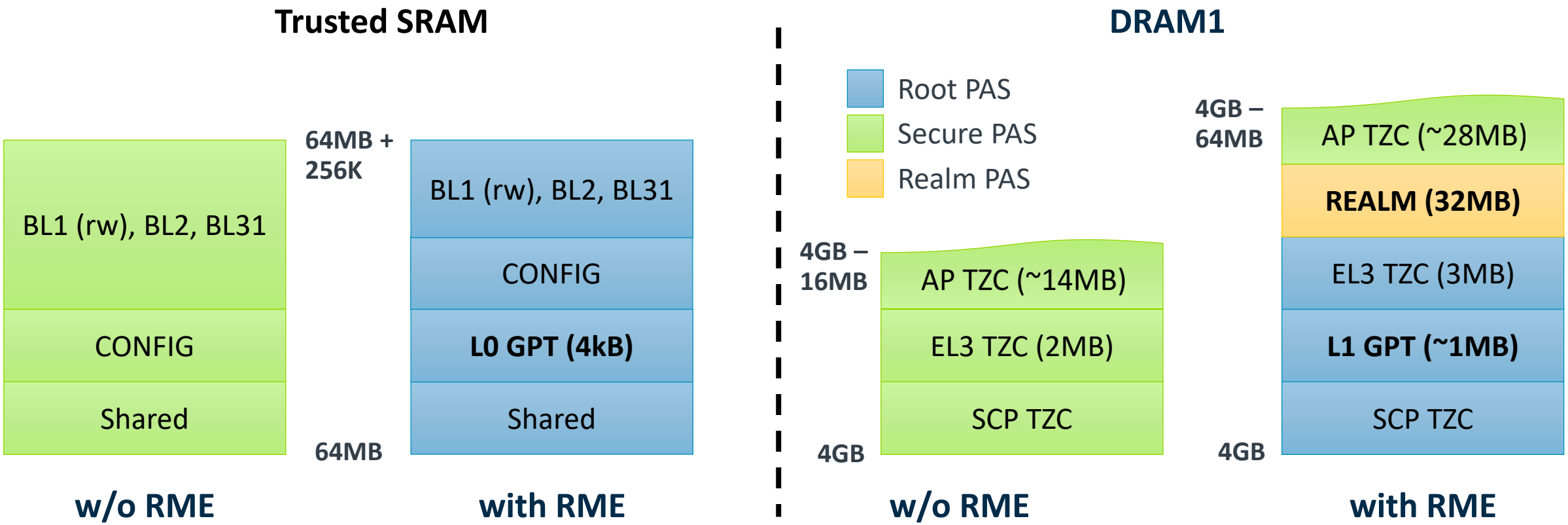


TF-A Changes – New additions

- RMM Dispatcher (RMMD)
  - New standard service, handles RMI SMC calls
- GPT library
  - Enables and initializes the GPT
  - Support for granule transition
- Test Realm Payload (TRP)
  - A small test payload that implements RMM functionalities
  - Supports transitioning granules from Non-secure to Realm world and vice versa

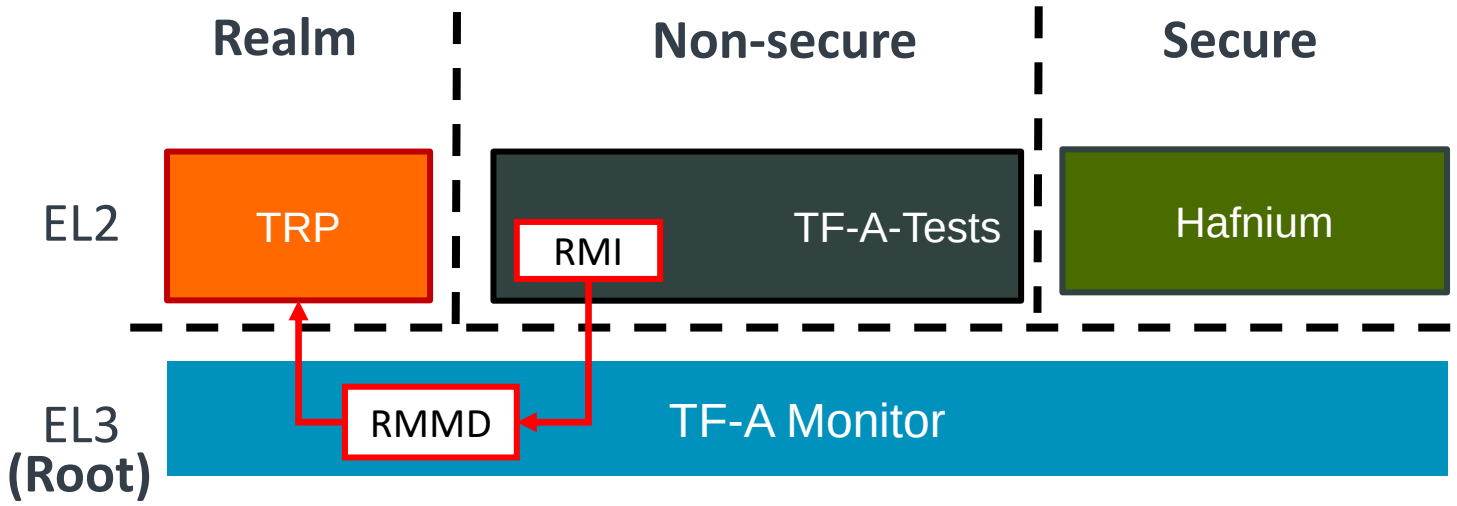
TF-A Changes – Platform changes

- RME support for the FVP platform
  - New memory carve-out



Testing the changes

- New tests added to **TF-A-Tests**
  - Test the RMI interface – Single CPU and multi-CPU granule transition tests



- All patches can be found at trustedfirmware.org

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Resources

- https://connect.linaro.org/resources/arm-cca
- https://developer.arm.com/documentation/den0125/latest
- https://developer.arm.com/documentation/ddi0615/latest

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Thank You
Danke
Gracias
谢谢
ありがとう
Asante
Merci
감사합니다
धन्यवाद
Kiitos
شكرًا
ধন্যবাদ
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