



Secure Systems in Focus: Challenges, Solutions, and Future Directions

seL4 Summit 2023

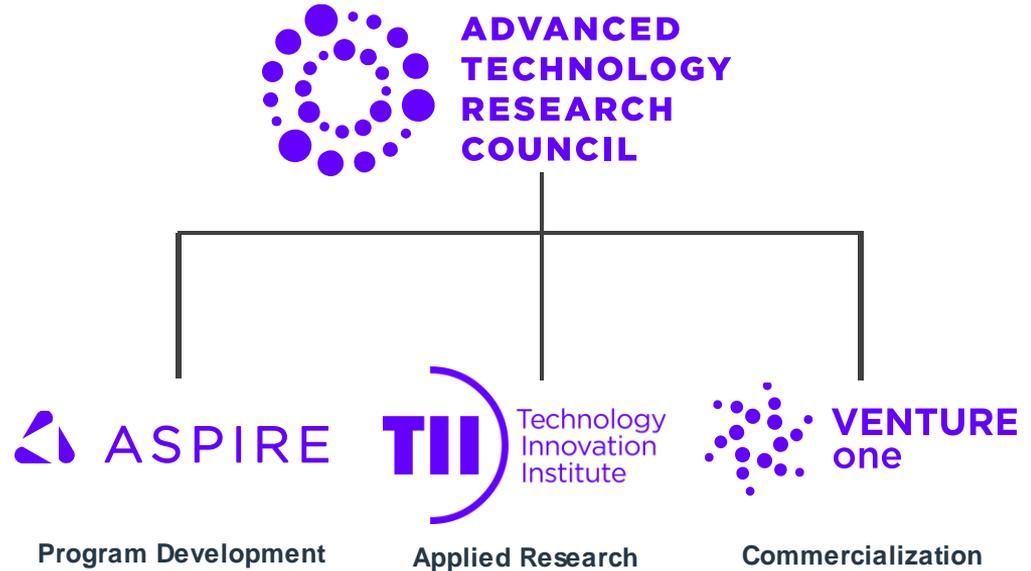
Everton de Matos
Secure Systems Research Center

Technology Innovation Institute (TII)

TII is the applied research arm of the Advanced Technology Research Council (ATRC).

TII is an **R&D Institute** focusing on **applied research** and advanced technology via dedicated **research Centers**.

Working with universities, research institutions, and industry partners worldwide, TII brings together an intellectual community and contributes to the **UAE's growing R&D ecosystem and knowledge-based economy**.



Priority Sectors



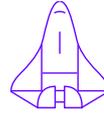
Healthcare



Sustainability,
Environment,
and Energy



Food and
Agriculture



Aerospace and
Space



Security and
Defence



Transportation

Research Centers



AI & Digital
Science



Advanced
Materials



Autonomous
Robotics



Biotech



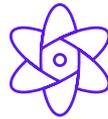
Cryptography



Directed
Energy



Propulsion &
Space



Quantum



Renewable &
Sustainable
Energy



Secure
Systems

Priority Sectors



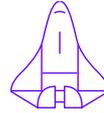
Healthcare



Sustainability,
Environment,
and Energy



Food and
Agriculture



Aerospace and
Space



Security and
Defence



Transportation

Research Centers



AI & Digital
Science



Advanced
Materials



Autonomous
Robotics



Biotech



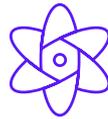
Cryptography



Directed
Energy



Propulsion &
Space



Quantum



Renewable &
Sustainable
Energy



Secure
Systems

Partnerships



SSRC Key Programs – Problem statement, End users & Solutions

Zero Trust Secure Autonomous UAS System

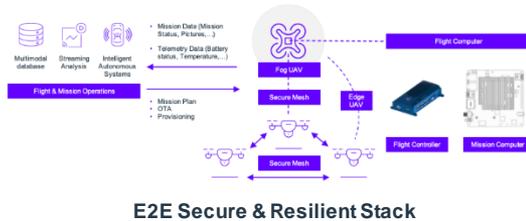
Problem Statement

Limited E2E Secure and resilient Autonomous systems

End Users

- First responders e.g., Police, Firefighters
- Military & Defense
- Logistics & service providers
- Smart Transportation
- Smart cities

Solutions



Secure Communications

Problem Statement

Current mesh based solutions does not support secure ad-hoc mobile peer to peer communication & scalability

End Users

- First responders e.g., Police, Firefighters
- Military & Defense
- Logistics & service provides
- Smart Transportation
- Smart cities

Solutions



Secure Mesh Shield SW Stack & Comms Module

Secure Technologies

Problem Statement

Current software and hardware stacks are thus hard to build secure, resilient, scalable & maintainable systems

End Users

- First responders e.g., Police, Firefighters
- Military & Defense
- Cyber security for enterprise
- Systems e.g., Secure UAS & Mesh

Solutions



Android Virtualization in cloud

Ghaf Framework

SSRC Key Programs – Problem statement, End users & Solutions

Zero Trust Secure Autonomous UAS System

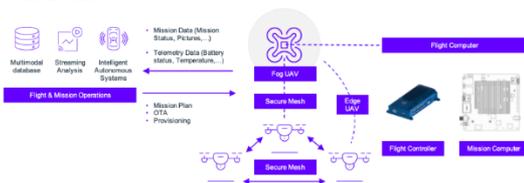
Problem Statement

Limited E2E Secure and resilient Autonomous systems

End Users

- First responders e.g., Police, Firefighters
- Military & Defense
- Logistics & service providers
- Smart Transportation
- Smart cities

Solutions



E2E Secure & Resilient Stack

Secure Communications

Problem Statement

Current mesh based solutions does not support secure ad-hoc mobile peer to peer communication & scalability

End Users

- First responders e.g., Police, Firefighters
- Military & Defense
- Logistics & service provides
- Smart Transportation
- Smart cities

Solutions



Secure Mesh Shield SW Stack & Comms Module

Secure Technologies

Problem Statement

Current software and hardware stacks are thus hard to build secure, resilient, scalable & maintainable systems

End Users

- First responders e.g., Police, Firefighters
- Military & Defense
- Cyber security for enterprise
- Systems e.g., Secure UAS & Mesh

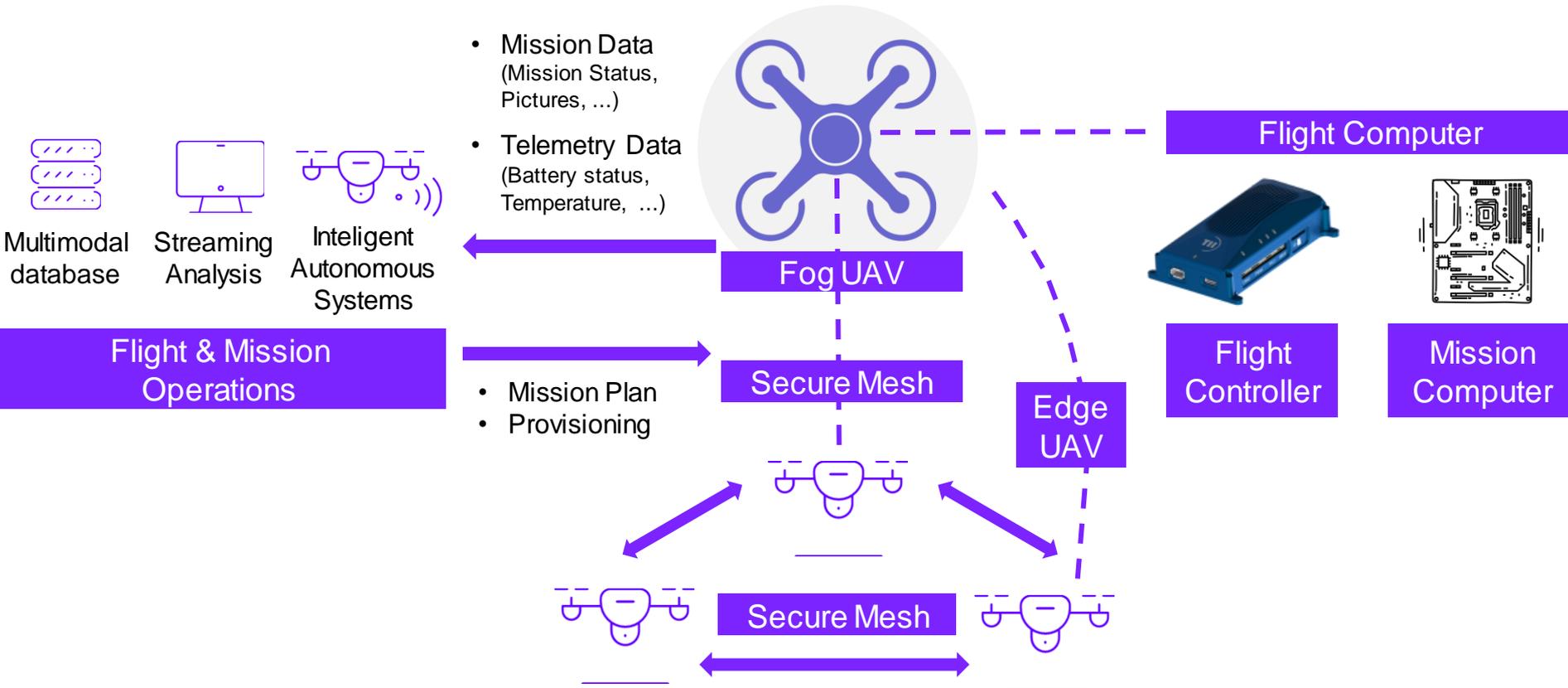
Solutions



Android Virtualization in cloud

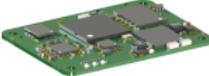
Ghaf Framework

TII SSRC Secure Autonomous UAS System



TII SSRC Secure Autonomous UAS System

Saluki Family of Flight Controller and Mission Computers

Saluki v1 (FC)	Saluki v2 (FC+LMC)	Saluki Pi (FC+LMC)	Saluki Pi Module (FC+LMC)	Saluki v3C <u>OEM</u> (FC+LMC+NvidiaMC+ Secure Mesh)	Saluki v3C (FC+LMC+NvidiaMC+ Secure Mesh)
					

SSRC Key Programs – Problem statement, End users & Solutions

Zero Trust Secure Autonomous UAS System

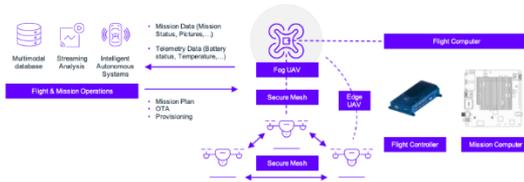
Problem Statement

Limited E2E Secure and resilient Autonomous systems

End Users

- First responders e.g., Police, Firefighters
- Military & Defense
- Logistics & service providers
- Smart Transportation
- Smart cities

Solutions



E2E Secure & Resilient Stack

Secure Communications

Problem Statement

Current mesh based solutions does not support secure ad-hoc mobile peer to peer communication & scalability

End Users

- First responders e.g., Police, Firefighters
- Military & Defense
- Logistics & service providers
- Smart Transportation
- Smart cities

Solutions



Secure Mesh Shield SW Stack & Comms Module

Secure Technologies

Problem Statement

Current software and hardware stacks are thus hard to build secure, resilient, scalable & maintainable systems

End Users

- First responders e.g., Police, Firefighters
- Military & Defense
- Cyber security for enterprise
- Systems e.g., Secure UAS & Mesh

Solutions



Android Virtualization in cloud

Ghaf Framework

TII SSRC Secure Technologies: Ghaf Framework

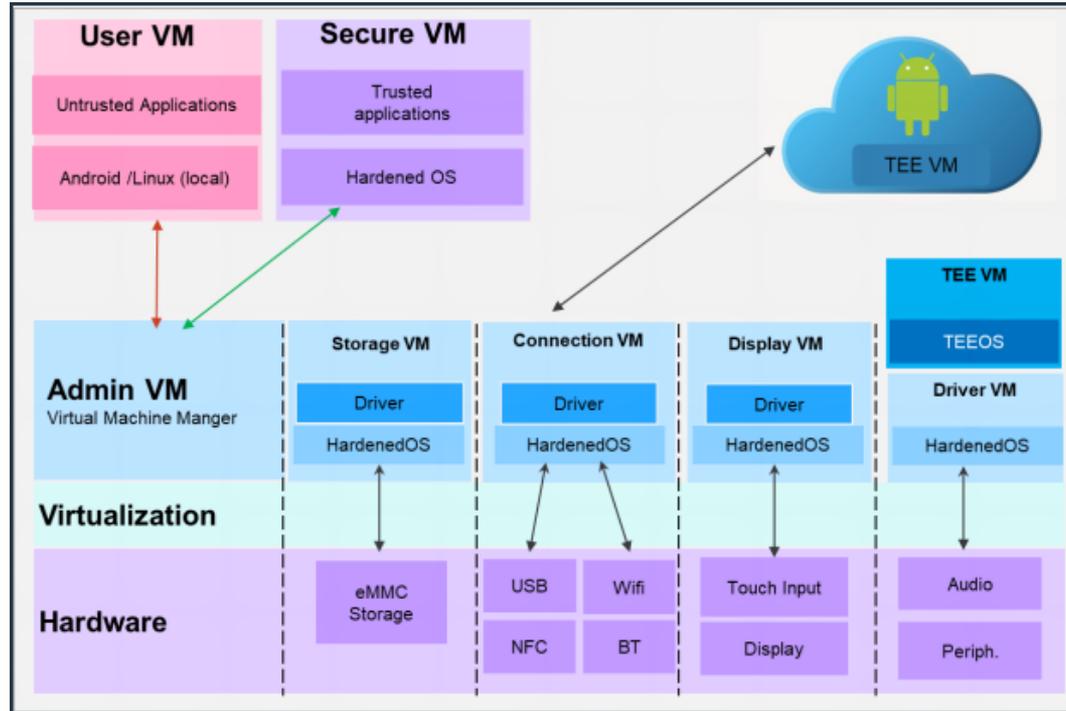
- The name “*Ghaf*” stems from the Ghaf tree, a highly resilient plant that remains green even in harsh desert environments
- The objective of **Ghaf** is to provide an **edge device software architecture** that enables key features such as:
 - **Modularity** and **scalability** through virtualization;
 - **Research and development** of Zero Trust Architecture (ZTA);
 - **Low maintenance** efforts while keeping the main code base stable and secure.



TII SSRC Secure Technologies: Ghaf Framework



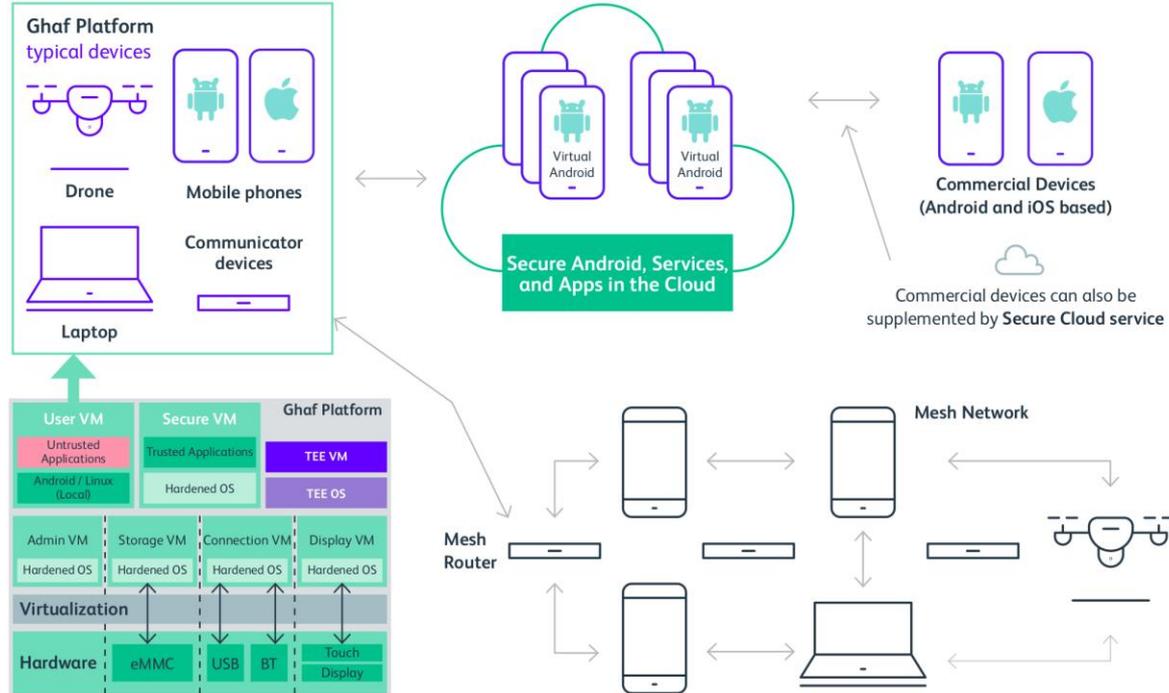
- Ghaf – Architecture



TII SSRC Secure Technologies: Ghaf Framework



- Ghaf – Product applications



TII SSRC Secure Technologies: Ghaf Framework

- Ghaf – Find out more



<https://github.com/tiuae/ghaf>



https://engineeringresources.spectrum.ieee.org/free/w_tecm10/prgm.cgi

TII SSRC Secure Technologies: seL4

- Developed an **architecture for embedded systems** use cases
 - seL4 as a **hypervisor**
 - Key component for a virtualized & isolated architecture – **virtual machines**
 - Building a PoC of a secure system for **feature rich** devices/ use cases
 - Open-source
 - Pull requests to **seL4 mainline**
 - seL4 as an **OS**
 - **TEE** on RISC-V PolarFire Icicle kit
 - SSRC Key Programs
- Member of the **seL4 Foundation**
- Talks at the **seL4 Summit 2022/2023**



TII SSRC Secure Technologies: seL4

tiiuae/tii_sel4_build



- Find out more

- Open source:

- https://github.com/tiiuae/tii_sel4_build

- Papers:

- *seL4 Microkernel for virtualization use-cases: Potential directions towards a standard VMM*
– Electronics, 2022 - <https://doi.org/10.3390/electronics11244201>
- *Improving Drone Mission Continuity in Rescue Operations with Secure and Efficient Task Migration*
– IEEE WF-IoT, 2022 - <https://doi.org/10.1109/WF-IoT54382.2022.10152279>
- *Enhancing System Security with seL4*
– IEEE Spectrum, 2023 - https://engineeringresources.spectrum.ieee.org/free/w_tecm09/prgm.cgi
- *Integrating VirtIO and QEMU on seL4 for Enhanced Devices Virtualization Support*
– IEEE TrustCom, 2023 – To be published





Thank you!

**Secure Systems in Focus:
Challenges, Solutions, and Future Directions**

seL4 Summit 2023

**Everton de Matos
Secure Systems Research Center**