Linux4Space.Org
A Reference Linux Distribution for Space Applications

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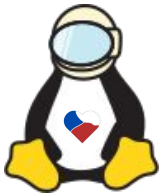

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#Linux4Space2023

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What is Linux For Space?

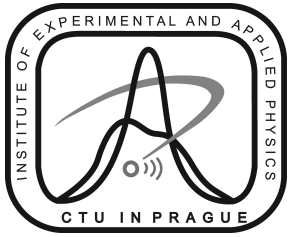
- Collaborative open source project.
- It was founded with the intention of creating an open source Yocto based Linux distribution suitable for the space applications.
- The project brings together all the stakeholders: the software and hardware developers, the suppliers, and technology companies.
- The Linux4Space is designed to be compliant with the ESA Standards (ECSS - European Cooperation for Space Standardization) and it is based on community defined requirements.

The Linux For Space has started in February 2022.

Linux4Space.org core team

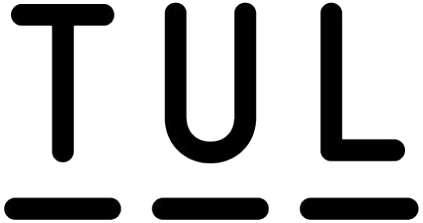
- Lenka Kosková Třísková & Lukáš Mázl, Technical University of Liberec
- Tomáš Novotný & Martin Sabol, Czech Aerospace Research Centre
- Javier Fernandez Salgado, TEC-SWF, ESTEC, ESA
- Eric Weiss, Linux Consultant, PREVAS
- Tim - Principal Software Engineer, Sony Electronics
- Kaiwan - Linux Author, Trainer, Consultant

Who we are?



Payloads for space.
Several running space realizations.
Requirements collection.

VZLUSAT-2 with Linux currently in space.
Requirements collection.



Web, project organization, propagation and management
Requirements collection
Project implementation

What we do

- All the information available at linux4space.org
- **Community regular meetings**
- **Knowlege gathering** (http://wiki.linux4space.org/)
- **Requirements gathering** (https://gitlab.com/linux4space/linux4space_requirements)
- **Standards analysis**
- **Implementation** (https://gitlab.com/linux4space/yocto)
- **Networking** (meetings, slack, other activities)

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Why are you interested in Linux4Space?

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Linux4Space Use Case

Linux4Space UseCase

- ***Payload system:*** Linux4Space is designed as the primary system for payload, not as the central platform system.
- ***No GUI*****:** Linux4Space does not provide any graphical user interface. It is designed as a system based with a text-based UI (terminal), or as a fully autonomous system or a system using a mission specific communication protocol.
- ***Real-time operation*****:** The Linux4Space shall guarantee the time determination of events processing.
- ***Space environment ready*****:** The system shall operate reliably and safely in a typical space physical environment, focusing on the effects of high temperature and radiation. The system can trigger a safe mode at defined conditions. It is capable of a fast shutdown and redundant critical data backup.

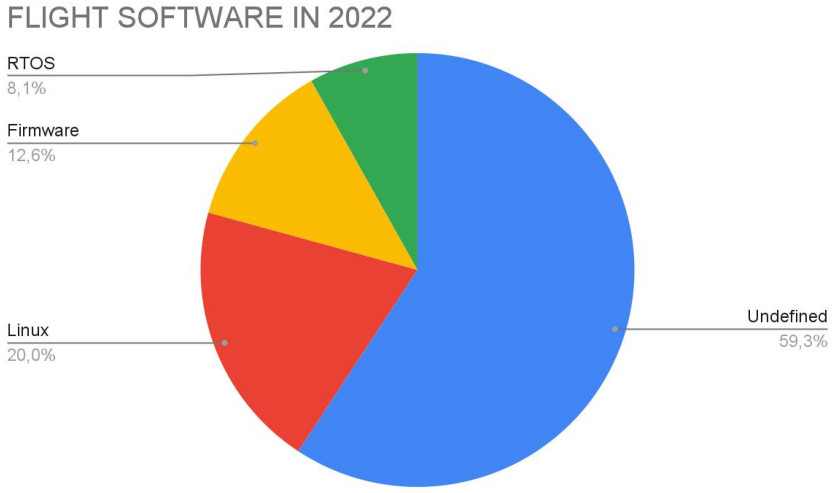
Linux4Space UseCase

- ***ESA Standards*:** The system is designed to be as close to all the software related ESA standards and recommendations as possible.
- ***YOCTO-based reference distribution*:** The system definition is a set of the YOCTO meta layers.
- ***Safety and reliability*:** The system design is coordinated with the outputs of the ELISA open-source project to keep the system safe and reliable for critical applications.
- ***Community-based*:** The Linux4Space is an open-source project open to everyone interested in Linux space applications.

Linux in Space (cubesats)

Linux in Space - CubeSats 2022

- Data includes unique CubeSat missions
- CubeSat may have multiple systems
  - RTOS for OBC
  - Linux for Payload
- How to find this information?
  - Pick a CubeSat launched in 2022
  - Find information about this CubeSat with keywords Linux, software, RTOS, and firmware.
  - If you have not found anything, mark this CubeSat as SW Undefined.
  - Repeat these steps until you get mad.



Other Linuxes in Space

Year	2019	2020	2021	2022
Launches	188	162	326	334
Linux (%)	(no data)	(no data)	~15%	~20%

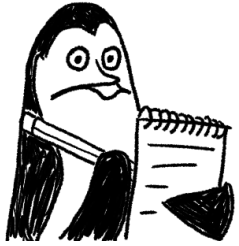
Linux4Space Wiki

- The main goal:

  We want to share all the information about the "Linux" and the "space" we already have.

- Our "role model" is the Embedded Linux wiki (elinux.org)
- We started the Wiki in April, providing a general structure, and continue adding content day by day.
- Everyone is welcome to add any information.
- Currently we are hosting the system with the help of the Technical University of Liberec.

Linux4Space - Requirements summary



Linux4Space Requirements

- To be ready for aero/space and critical applications, traceable design important
- It means to go from requirements to implementation and have the test specification with the verification from the beginning
- The Requirements up to now were defined by the core group in 2022 and at the beginning of 2023 (the output in public github)

Linux4Space Requirements Summary

- “The Space” = Environment = Radiation:
  - The system shall switch off immediately.
    - The filesystems used to store mission critical data shall mostly work in read-only mode.
- Interfaces:
  - SpaceWire, SpaceFibre
  - CubeSat Space Protocol
- Power constraints:
  - The system shall have a configuration to define the process with a certain power budget.
- Not so much safety/reliability regarding the kernel itself
- Reporting, environment information etc.

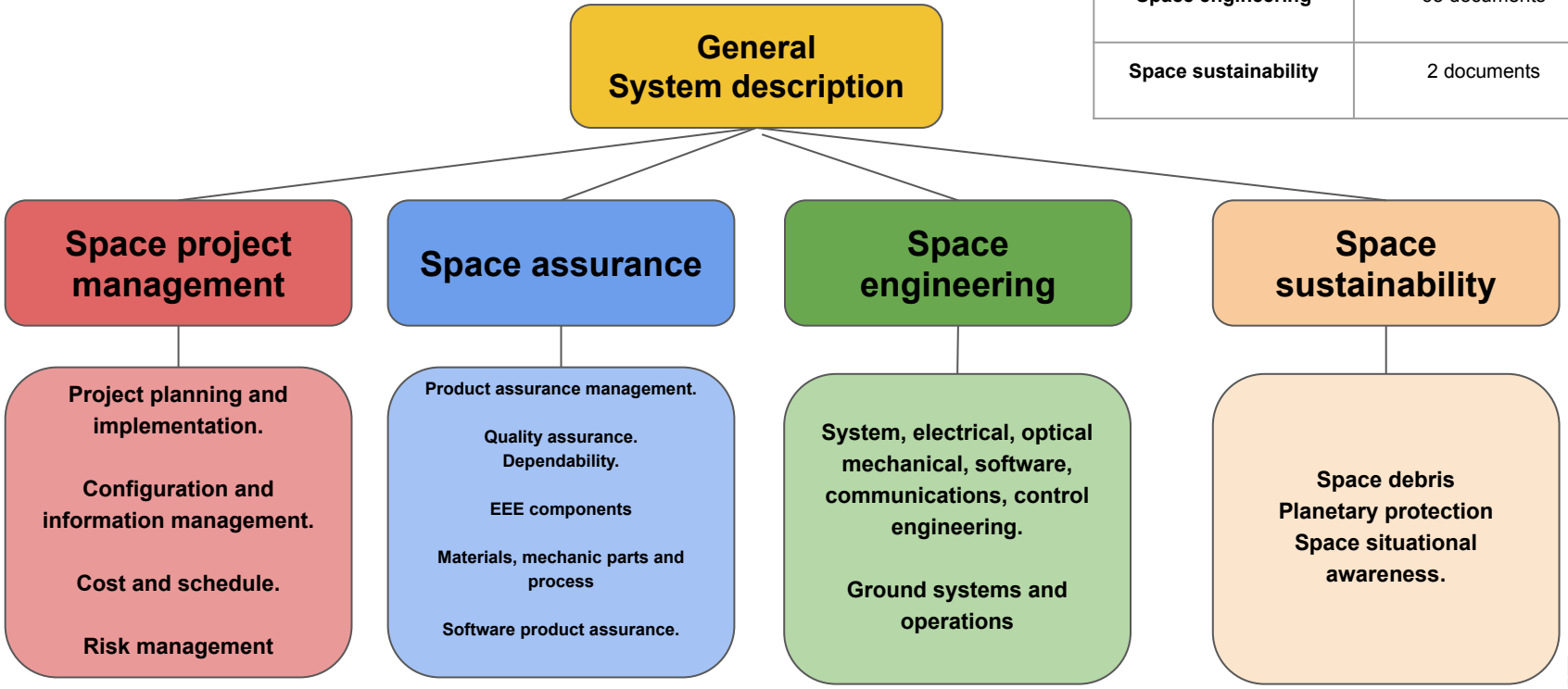
From Requirements to Implementation

- The main decission: yocto-based open source
- Each of requirements has ID and an attribute “yocto”
- We want to keep the track form the requirements to the implementation, recipes etc.
- The main stakeholders: the core group and partners, for future also the related ECSS

Path to ECSS compliance

ECSS system of standards in general

Space project management	6 documents
Space assurance	62 documents
Space engineering	65 documents
Space sustainability	2 documents

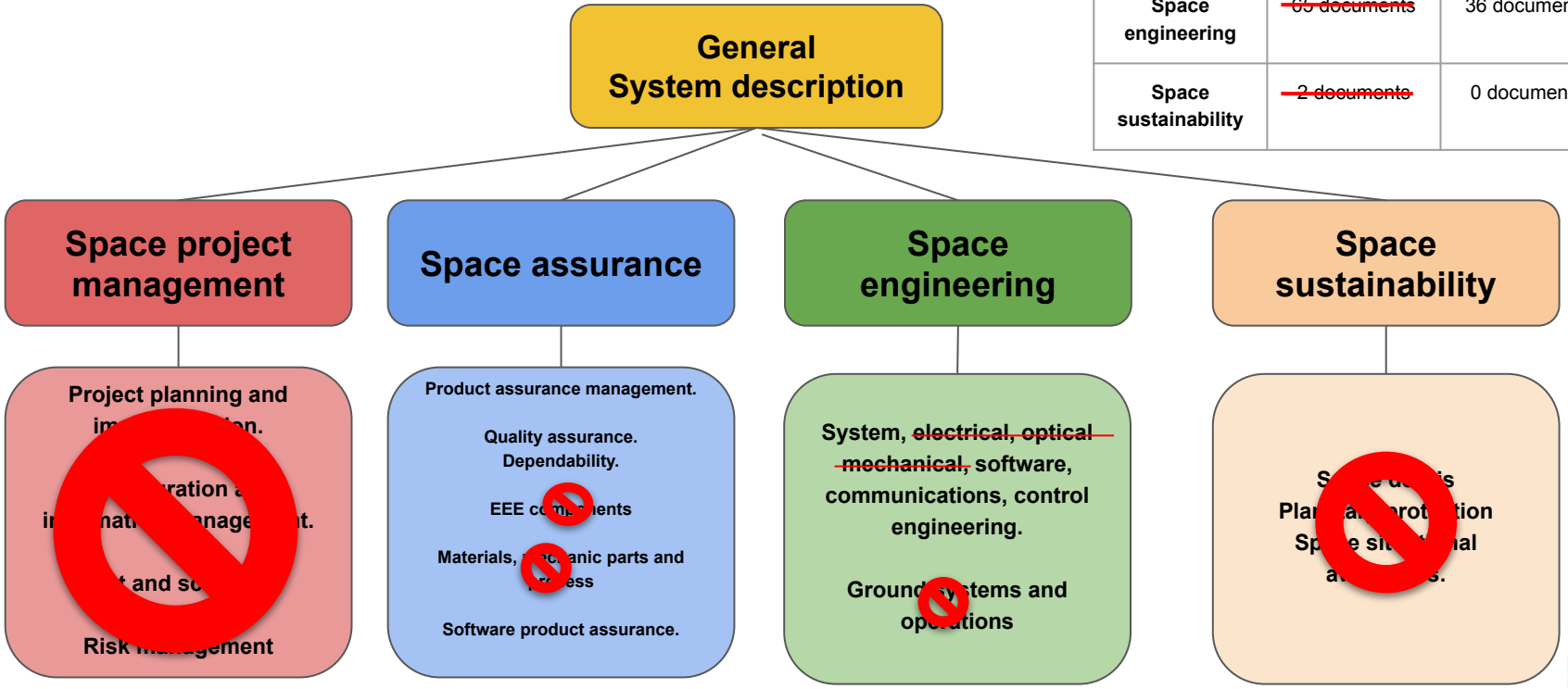


ECSS related to Linux4Space

- Linux4Space shall be as close to ECSS as possible
- Relevant document selection by these rules:
  - Include documents focusing on:
    - Software engineering
    - IO Communication (Drivers)
  - Exclude irrelevant documents focusing on:
    - Material
    - Mechanical
    - Electrical

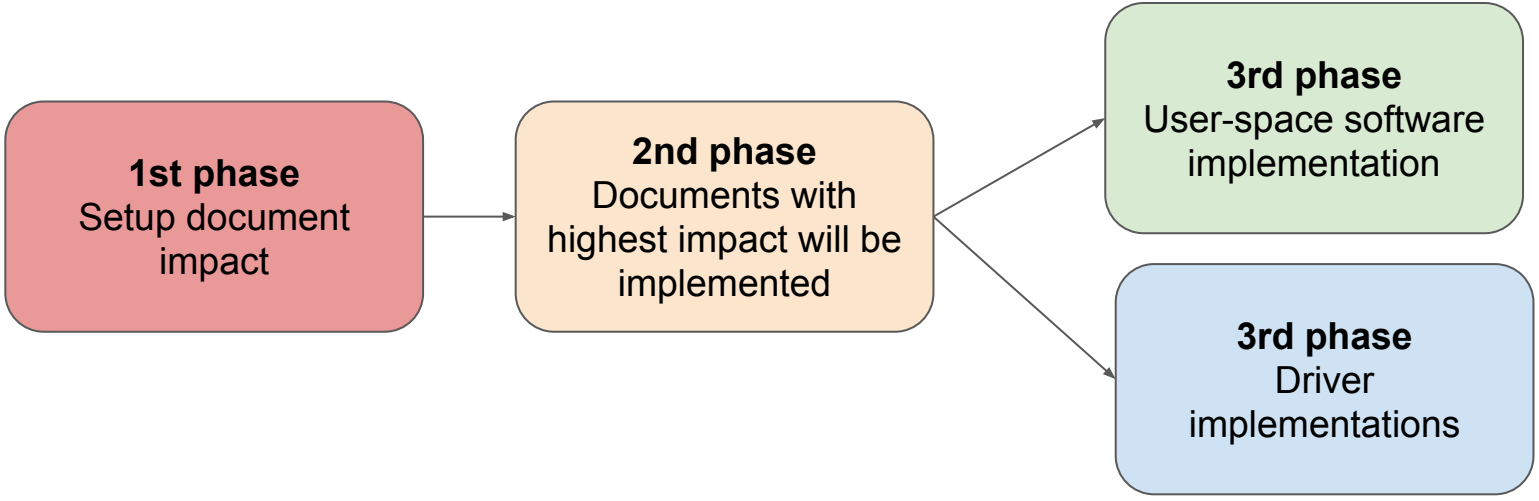
ECSS related to Linux4Space

Space project management	~~6 documents~~	0 documents
Space assurance	~~62 documents~~	9 documents
Space engineering	~~65 documents~~	36 documents
Space sustainability	~~2 documents~~	0 documents



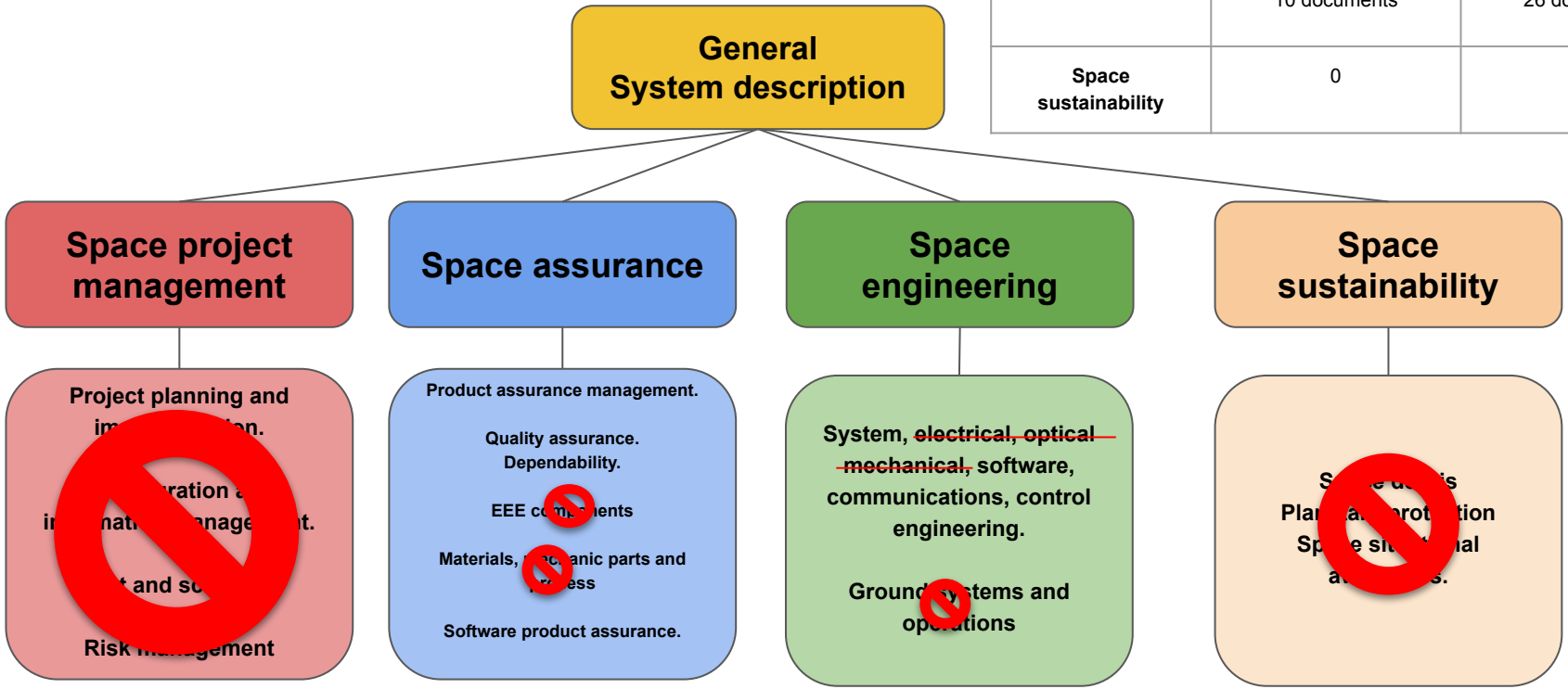
ECSS implementation strategy

- We defined impact attributes for document as follow:
  - Document has impact on whole project (Documents with the highest impact)
  - Document has impact on unique user-space software
  - Document has impact on drivers
  - Document is unrelated to our project (Documents with the lowest impact)



ECSS related to Linux4Space

Space project	0	0
Space assurance	2st phase: 7 documents	3rd phase: 2 documents
Space engineering	2st phase: 10 documents	3rd phase: 26 documents
Space sustainability	0	0



Linux4Space Yocto Structure

General principles

- From requirements to yocto implementation
- Layers shall be added to existing yocto structure with any BSP
- 3 HW references: Raspberry Pi, VZLU, qemu

We shall try to keep the main layers as HW independent as possible

Linux4Space Layers

- System Layer, meta-linux4space:
  - The main distro configuration
  - Image definition
  - Kernel related recipes
  - Bootloader related recipes
  - All the kernel-space applications
  - System configuration
- Application Layer, meta-linux4space-app
  - The applications for the space use case
  - e.g., the app responsible for creating the diagnostic reports
  - Telemetry, navigation… everything not required to work in the kernel-space

Linux4Space

meta-linux4space-app
(as close to ECSS as possible)
Useful apps for space, working in user-space (communication protocols, reporting etc.)

meta-space
(nobody checked the ECSS)
useful space apps

meta-linux4space
(as close to ECSS as possible)
System related: boot, image selection, update, upgrade, interfaces…
Image definitions

HW related stuff

BSP Board with iMX

BSP Raspberry Pi

BSP PetaLinux

BSP Freescale

"Normal embedded stuff"

OpenEmbedded ("main yocto")

From Requirements to Yocto

The requirement model has attribute named *yocto* for each of requirement.

Possible values:

- Distro feature.
- Recipe System Layer.
- Recipe Application Layer.
- Not Yocto related.
- Not yet defined.

Recipe System Layer

- A functionality has to be:
  - Configured for and existing package (provided config etc.)
  - Programmed (provided source code with configuration and other stuff).
- Why in System Layer? Required functionality needs to:
  - Update the bootloader
  - Update the kernel
  - Be a part of system services
- Example:
  - Random image selection during boot
  - Checksum for the rootfs
  - Idle mode and other modes of operation

Recipe App Layer

- Required Functionality is not necessary for the system.
- Required Functionality may be implemented as an application/service working in the user space.
- No bootloader/kernel source code/configuration update needed.
- Example:
  - Collecting and reporting the diagnostic information.
  - Service with configuration in /etc, preinstalled if required.

GitLab organisation

The public group Linux4Space (https://gitlab.com/linux4space):

Subgroups:

- Linux4Space Requirements:
  - A requirement model
  - The “human readable exports” from rexif and related xsl sheets
- yocto:
  - linux4space-meta
  - linux4space-meta-app
  - space-meta
- Linux4Space yocto:
  - Links together all the meta-layers and creates the working directory for the target HW

Reference hardware

- General useful and popular HW/emulators:
  - Qemu & x86
  - Raspberry Pi
- Space-ready HW:
  - The VZLU board
  - RISC-V (there is a space ready NOEL-V)

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Q&A