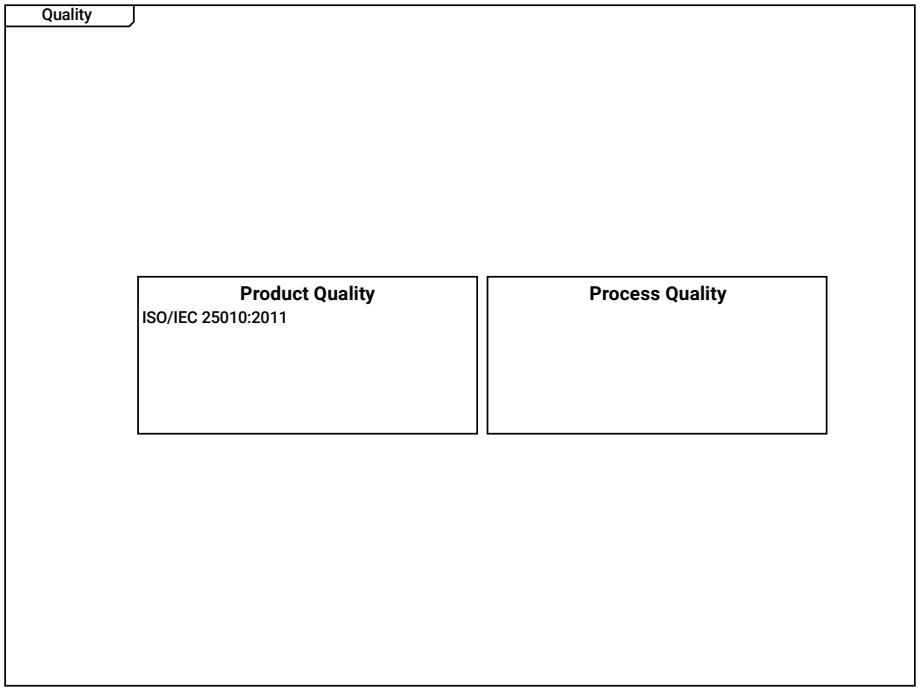
1 Quality Example

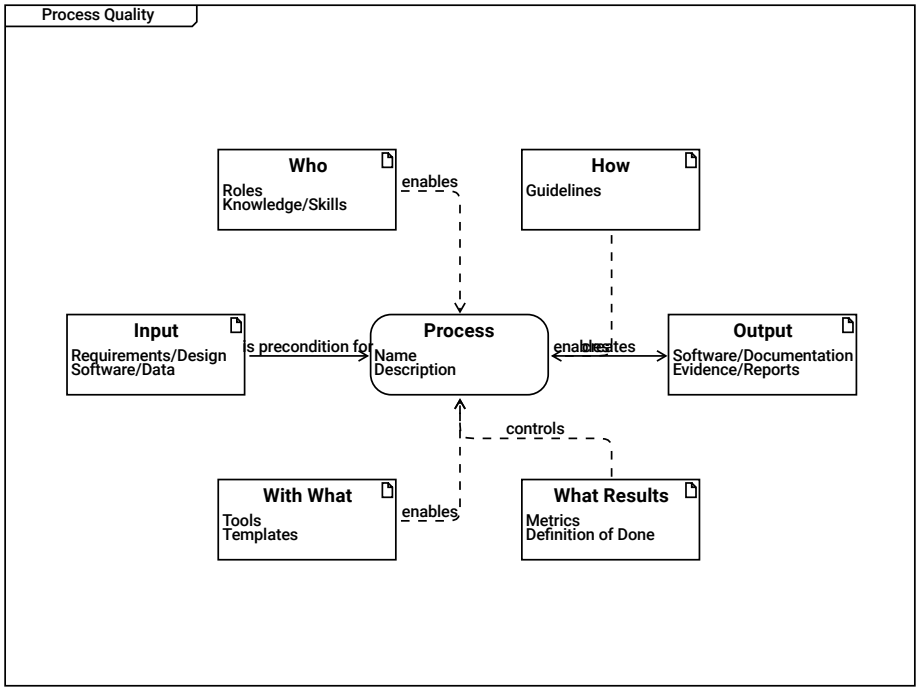



```
Quality


Product Quality
  ISO/IEC 25010:2011


Process Quality
```

2 Process Quality




```
Process Quality
| The turtle diagram shows the elements of a process.


Who
| Roles,
| Skills, Knowledge,
| Trainings
  Roles
  Knowledge/Skills
  enables --> Process


How
| Guidelines, Checklists,
| Templates
  Guidelines
  enables --> Process


Input
```

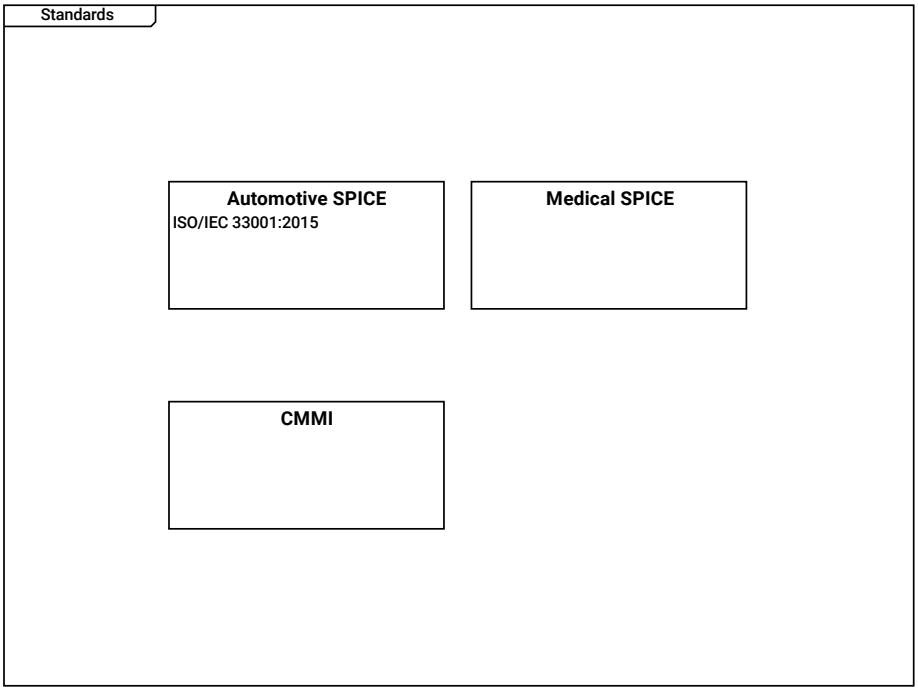
```
  Requirements/Design
  Software/Data
  is precondition for --> Process


Process
  Name
  Description
  creates --> Output


Output
| Process output,
| Evidence on performed process
  Software/Documentation
  Evidence/Reports


With What
  Tools
  Templates
  enables --> Process


What Results
  Metrics
  Definition of Done
  controls --> Process
```

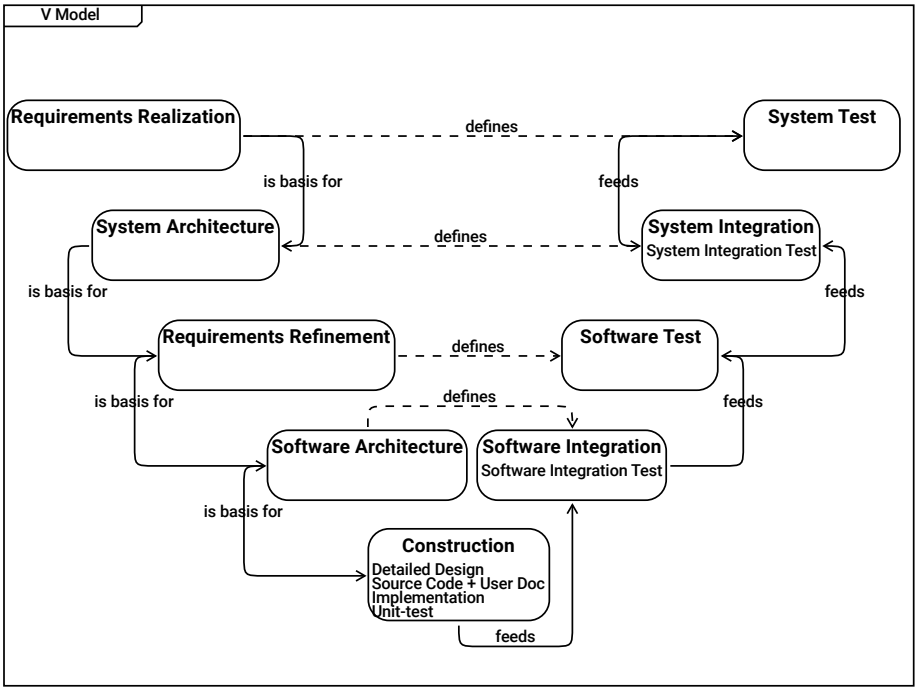


Standards

Automotive SPICE
  ISO/IEC 33001:2015

Medical SPICE

CMMI



V Model

Requirements Realization
  is basis for --> System Architecture
  defines --> System Test

System Test

System Architecture
  is basis for --> Requirements Refinement
  defines --> System Integration

System Integration
  System Integration Test
  feeds --> System Test

Requirements Refinement
  is basis for --> Software Architecture

```
  defines --> Software Test

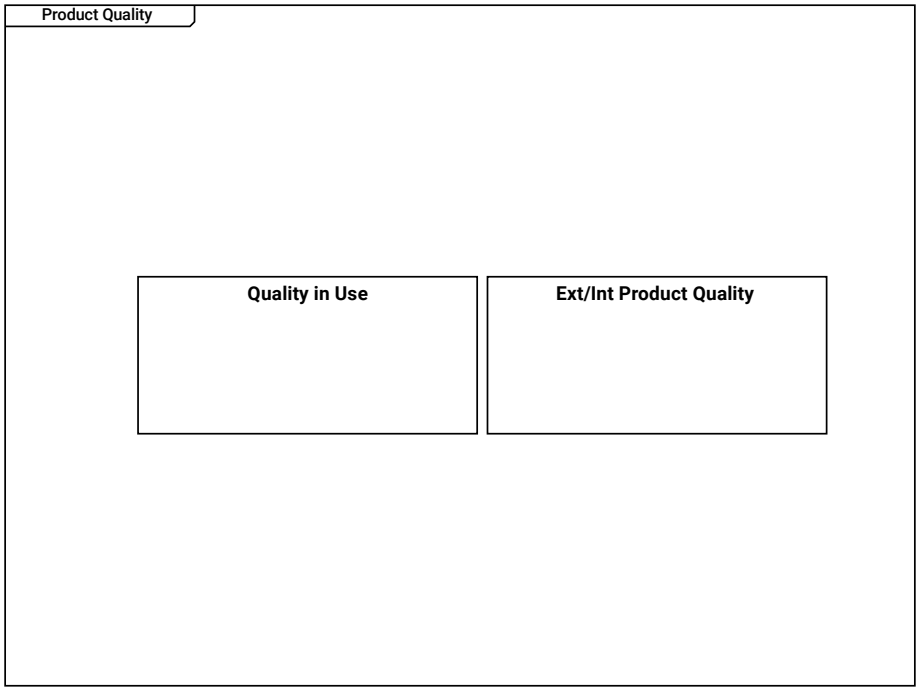

Software Test
  feeds --> System Integration


Software Architecture
  defines --> Software Integration
  is basis for --> Construction


Software Integration
  Software Integration Test
  feeds --> Software Test


Construction
  Detailed Design
  Source Code + User Doc
  Implementation
  Unit-test
  feeds --> Software Integration
```

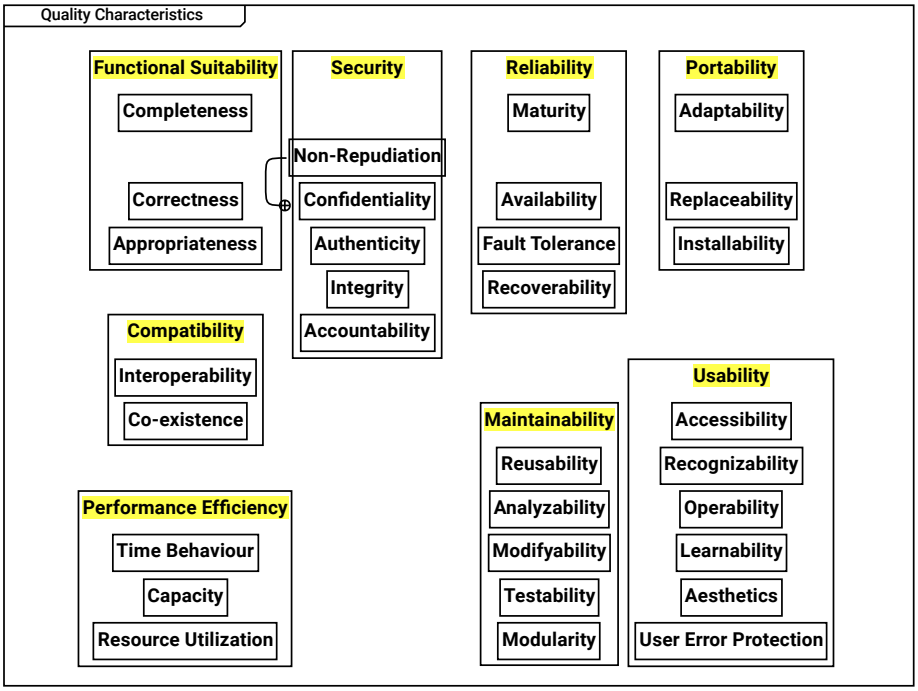
3 Product Quality



Product Quality

Quality in Use
| Quality in use can be measured when the product is already in use,
| e.g. the percentage of satisfied customers can be determined.

Ext/Int Product Quality
| Product quality are internal and externally visible qualities,
| such as memory consumption or startup timings.




```
Quality Characteristics
| according to ISO 25010


Functional Suitability
   --> Completeness
   --> Correctness
   --> Appropriateness


Security
   --> Authenticity
   --> Non-Repudiation
   --> Accountability
   --> Integrity
   --> Confidentiality


Reliability
   --> Maturity
   --> Availability
   --> Fault Tolerance
   --> Recoverability
```

```
Portability
   --> Adaptability
   --> Installability
   --> Replaceability


Completeness


Maturity


Adaptability


Non-Repudiation


Correctness


Confidentiality


Availability


Replaceability


Appropriateness


Authenticity


Fault Tolerance


Installability


Integrity
```

```
Recoverability


Compatibility
   --> Co-existence
   --> Interoperability


Accountability


Interoperability


Usability
   --> Recognizability
   --> Learnability
   --> Operability
   --> User Error Protection
   --> Aesthetics
   --> Accessibility


Co-existence


Maintainability
   --> Testability
   --> Modifyability
   --> Analyzability
   --> Reusability
   --> Modularity


Accessibility


Reusability


Recognizability


Performance Efficiency
   --> Time Behaviour
```

```
   --> Resource Utilization
   --> Capacity


Analyzability


Operability


Time Behaviour


Modifyability


Learnability


Capacity


Testability

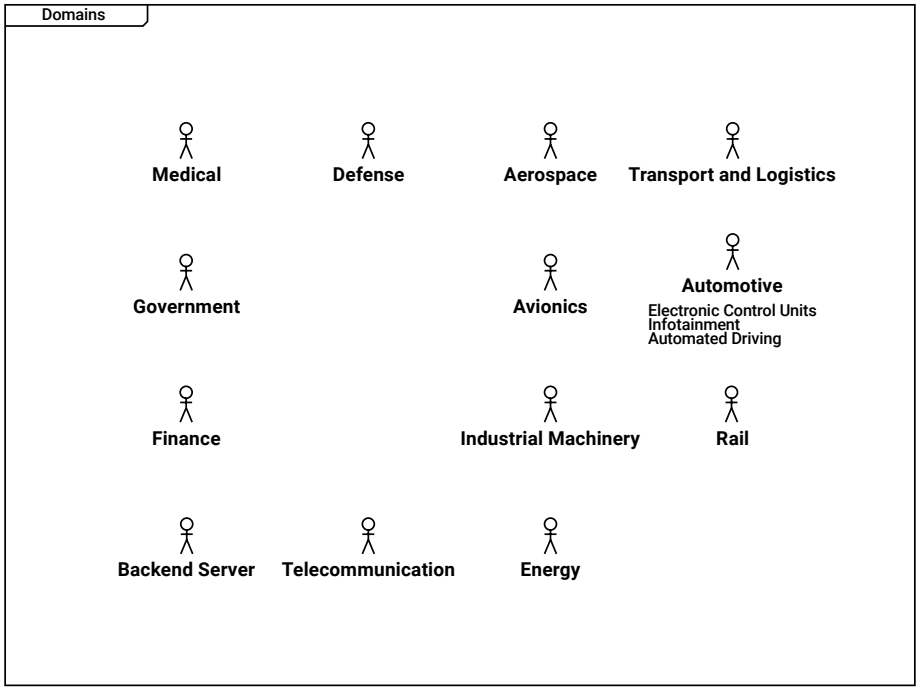

Aesthetics


Resource Utilization


Modularity


User Error Protection
```

3.1 Product Quality Measures



Domains

Medical

Defense

Aerospace

Transport and Logistics

Government

Avionics

Automotive

Electronic Control Units
Infotainment
Automated Driving

Finance

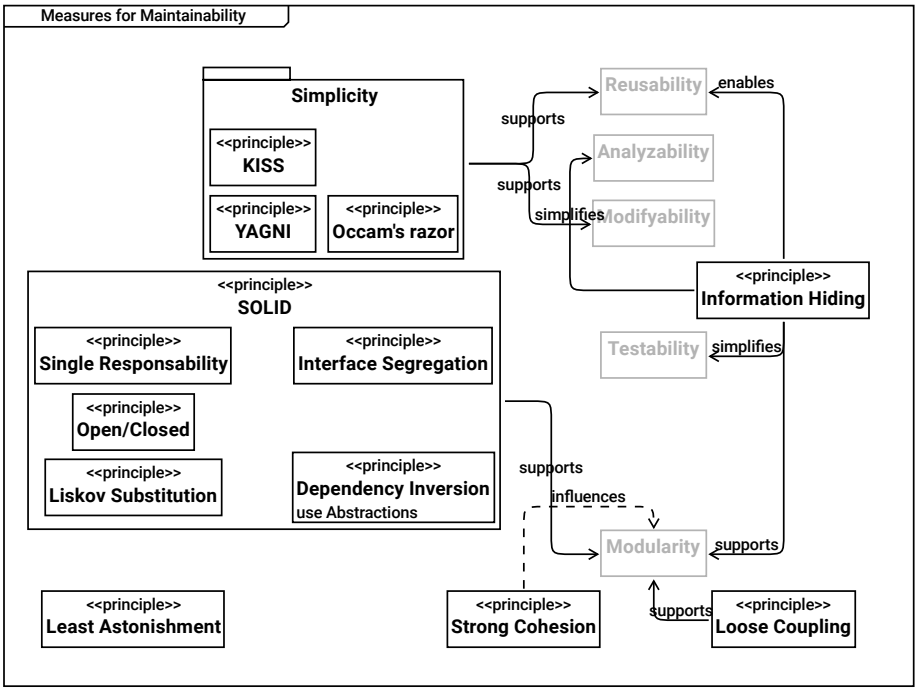
Industrial Machinery

Rail

Backend Server

Telecommunication

Energy



Measures for Maintainability

```
Simplicity
   --> KISS
   --> YAGNI
   --> Occam's razor
  supports --> Modifyability
  supports --> Reusability


Reusability


KISS
| Keep it simple and stupid


Analyzability


YAGNI
| You aren't gonna need it


Occam's razor
| Among competing hypotheses, the one with the fewest assumptions should be selected


Modifyability


Information Hiding
| A sofware component shall hide its implementation details and make information accessible
  enables --> Reusability
  supports --> Modularity
  simplifies --> Testability
  simplifies --> Analyzability


Single Responsability
| A software component shall be responsible for one topic only


SOLID
   --> Interface Segregation
   --> Liskov Substitution
   --> Dependency Inversion
```

```
   --> Open/Closed
   --> Single Responsability
  supports --> Modularity


Interface Segregation
| Avoid general purpose interfaces, design multiple interfaces specific to the needs of dif


Testability


Open/Closed
| Open for extension, closed for modification


Liskov Substitution
| An implementation of an interface can be replaced by another implementation of the same i

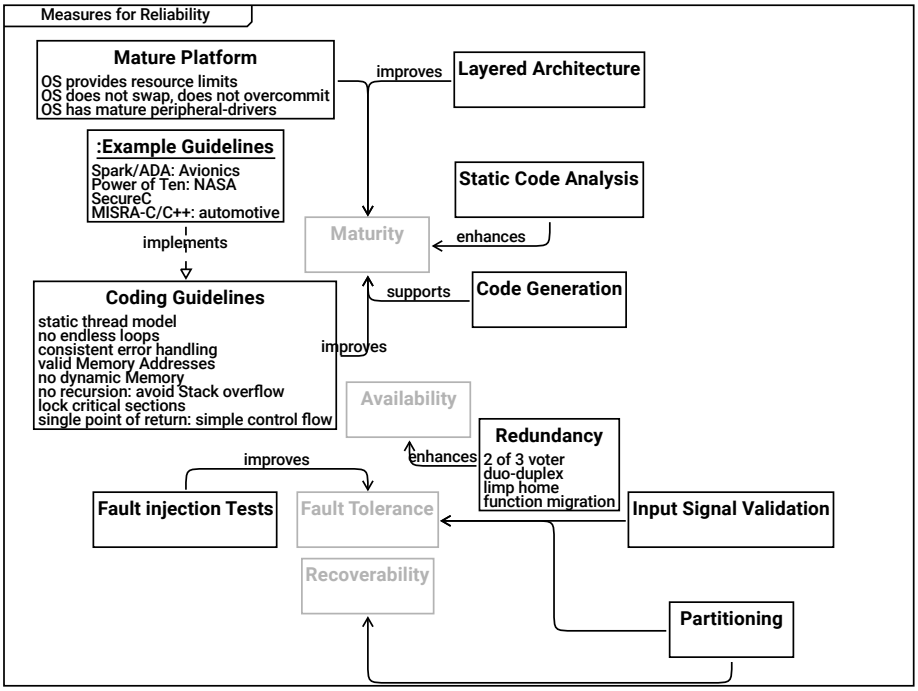

Dependency Inversion
| A software component shall depend on abstractions, not on concrete implementations
  use Abstractions


Modularity


Least Astonishment
| If a reader is astonished when looking at the design, a redesign shall be considered.
| Measure: Conformity of style and concepts


Strong Cohesion
  influences --> Modularity


Loose Coupling
| split an entity that consists of multiple loosely coupled parts
  supports --> Modularity
```




```
Measures for Reliability


Mature Platform
  OS provides resource limits
  OS does not swap, does not overcommit
  OS has mature peripheral-drivers
   --> Maturity


Layered Architecture
  improves --> Maturity


Example Guidelines
  Spark/ADA: Avionics
  Power of Ten: NASA
  SecureC
  MISRA-C/C++: automotive
  implements --> Coding Guidelines


Static Code Analysis
```

```
  enhances --> Maturity


Maturity


Code Generation
| An understandable model and a small code generator
| allow to generate mature software.
  supports --> Maturity


Coding Guidelines
  static thread model
  | Execution threads shall not be started/stopped dynamically
  no endless loops
  | Every loop shall have a counter to ensures that
  | after a predefined maximum value the loop is definitely quit
  consistent error handling
  | Inconsistencies in error handling make
  | bugs in error handling more likely
  valid Memory Addresses
  | Only valid memory addresses may be read/written.
  | E.g. Java solves this by prohibiting pointers,
  | In C/C++, check pointers and array indices before usage
  no dynamic Memory
  | When the program is running,
  | - it must not fail due to
  |   - memory fragmentation (virtual addresses/physical pages)
  |   - out of memory situations
  | - it shall have a defined timing (which new/malloc cannot provide)
  no recursion: avoid Stack overflow
  lock critical sections
  | Always lock critical sections.
  | Exceptions to locking are a nightmare.
  single point of return: simple control flow
  | Simple control flow is key to understandable code
  improves --> Maturity


Availability


Redundancy
  2 of 3 voter
  duo-duplex
```

```
  limp home
  function migration
  enhances --> Availability

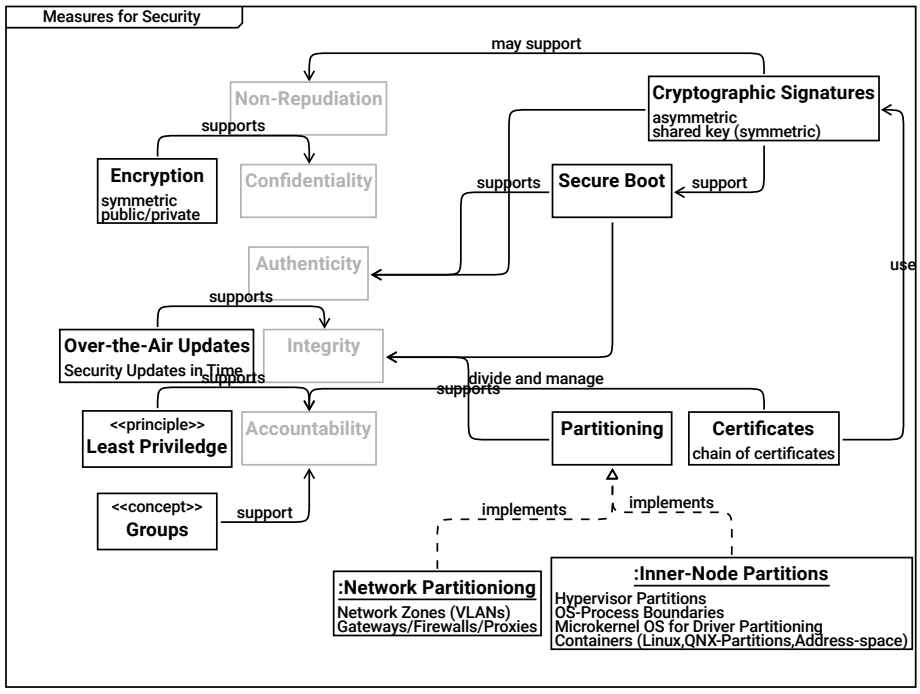

Fault injection Tests
  improves --> Fault Tolerance


Fault Tolerance


Input Signal Validation
   --> Fault Tolerance


Recoverability


Partitioning
   --> Fault Tolerance
   --> Recoverability
```




```
Measures for Security
```

```
| Functional safety and security are different goals
| but have common mechanisms to support these.
|
| The diagram is not meant to be complete,
| it just shows that technical mechanisms support quality goals.


Non-Repudiation


Cryptographic Signatures
  asymmetric
  shared key (symmetric)
  supports --> Authenticity
  may support --> Non-Repudiation
  support --> Secure Boot


Encryption
  symmetric
  public/private
  supports --> Confidentiality


Confidentiality


Secure Boot
   --> Integrity
   --> Authenticity


Authenticity


Over-the-Air Updates
  Security Updates in Time
  supports --> Integrity


Integrity


Least Priviledge
| Entities shall have only the access rights they need for their purpose
  supports --> Accountability
```

```
Accountability

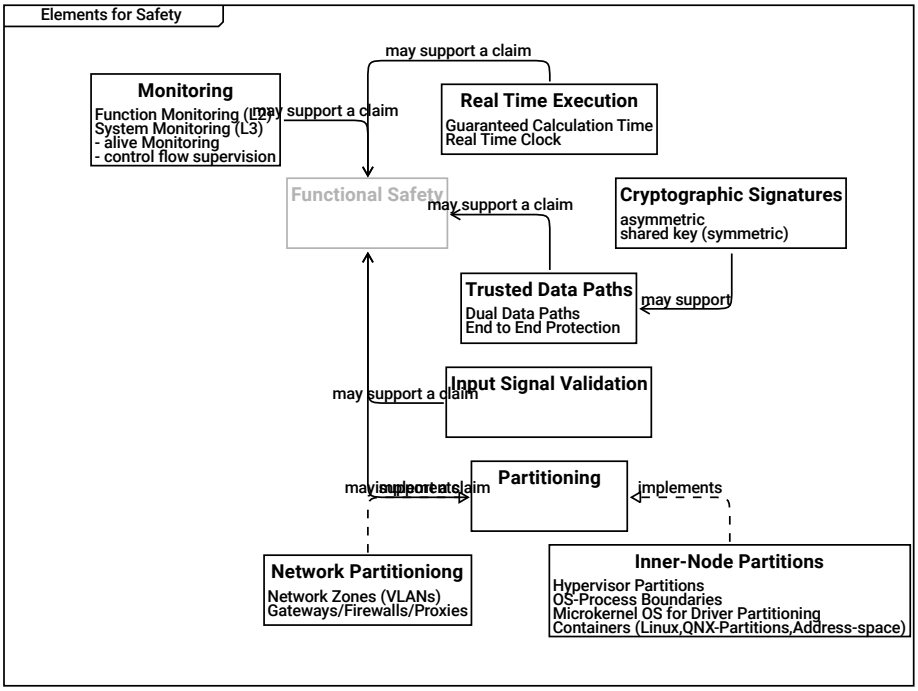

Partitioning
  supports --> Integrity


Certificates
  chain of certificates
  use --> Cryptographic Signatures
  divide and manage --> Accountability


Groups
| Grouping Clients/Actors helps
| Grouping Services
| helps in administration of access rights
  support --> Accountability


Network Partitioniong
  Network Zones (VLANs)
  Gateways/Firewalls/Proxies
  implements --> Partitioning


Inner-Node Partitions
  Hypervisor Partitions
  OS-Process Boundaries
  Microkernel OS for Driver Partitioning
  Containers (Linux,QNX-Partitions,Address-space)
  implements --> Partitioning
```




```
Elements for Safety


Monitoring
  Function Monitoring (L2)
  System Monitoring (L3)
  - alive Monitoring
  - control flow supervision
  may support a claim --> Functional Safety


Real Time Execution
  Guaranteed Calculation Time
  Real Time Clock
  may support a claim --> Functional Safety


Functional Safety


Cryptographic Signatures
  asymmetric
  shared key (symmetric)
```

```
  may support --> Trusted Data Paths


Trusted Data Paths
  Dual Data Paths
  End to End Protection
  may support a claim --> Functional Safety


Input Signal Validation
  may support a claim --> Functional Safety


Partitioning
  may support a claim --> Functional Safety


Network Partitioniong
  Network Zones (VLANs)
  Gateways/Firewalls/Proxies
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