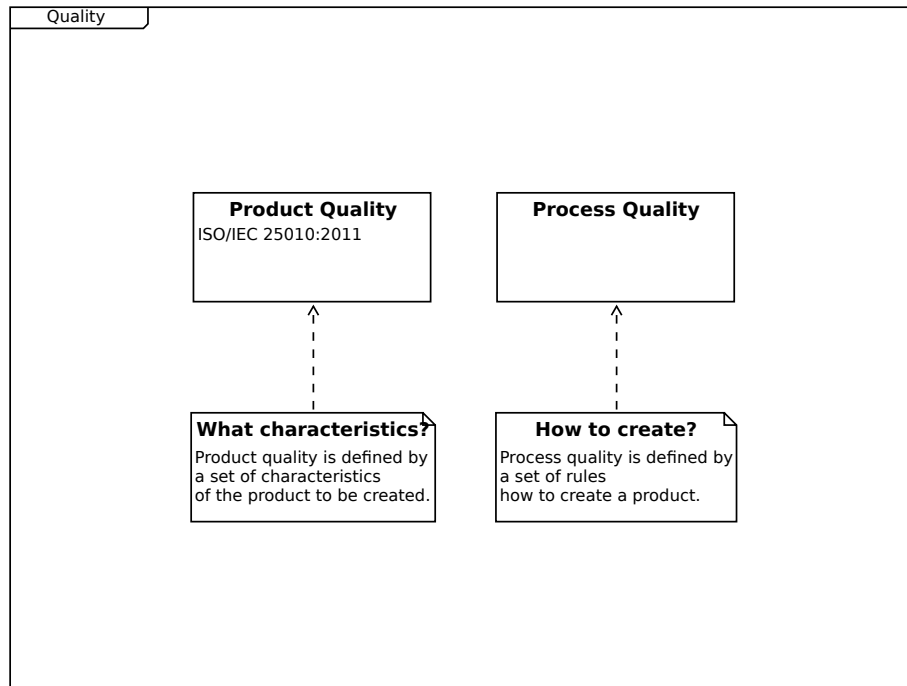


# 1 Quality Example



Quality [D0001]  
| Quality is a set of characteristics of a product.  
| These characteritics can be measured.

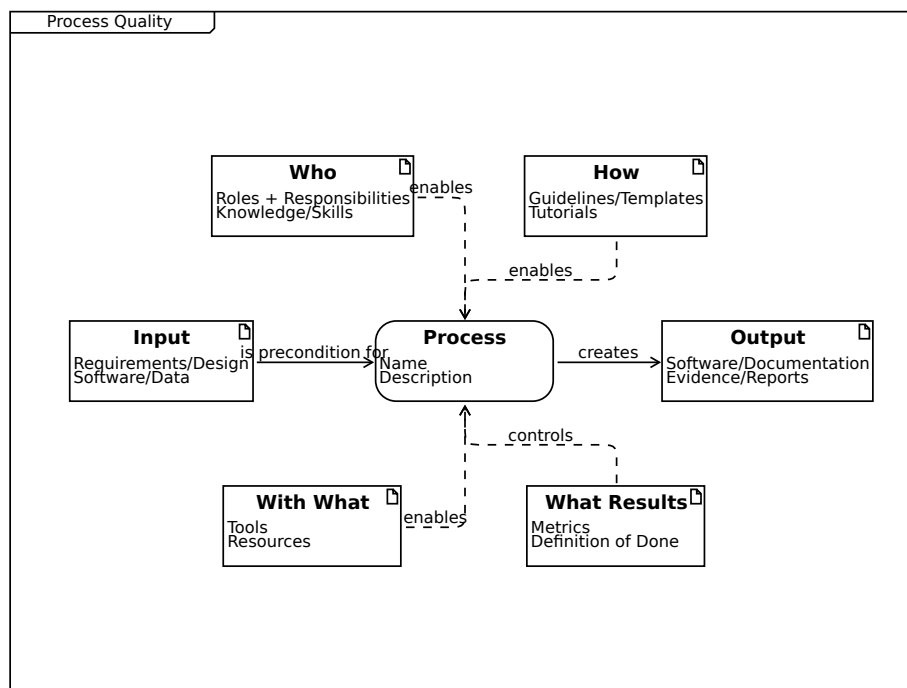
Process Quality [C0001]  
| Process quality can be measured by analyzing the reports and other workproducts  
| that have been created during different phases at engineering and during operation.

Product Quality [C0002]  
| Product quality refers to characteristics that can be measured  
| by analyzing the product that was created and that is in use.  
ISO/IEC 25010:2011 [F0004]

How to create? [C0115]  
| Process quality is defined by  
| a set of rules  
| how to create a product.  
--> Process Quality [R0131]

What characteristics? [C0116]  
 | Product quality is defined by  
 | a set of characteristics  
 | of the product to be created.  
 --> Product Quality [R0132]

## 2 Process Quality

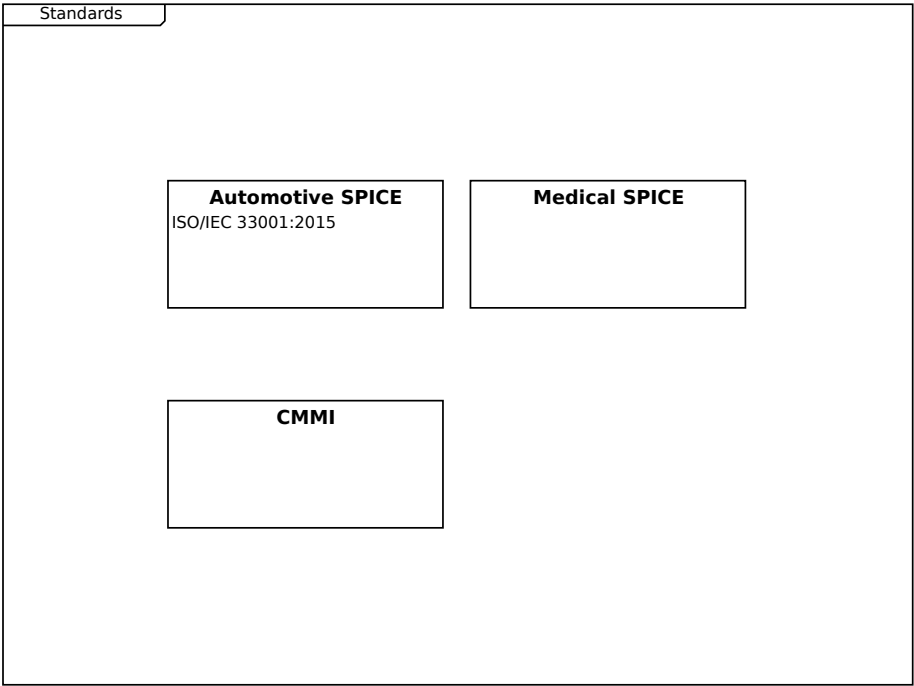


Process Quality [D0003]  
 | The turtle diagram shows the elements of a process.

Process [C0005]  
 Name [F0011]  
 Description [F0012]  
 creates --> Output [R0002]

With What [C0006]  
 Tools [F0050]  
 Resources [F0051]

enables --> Process	[R0003]
Output	[C0007]
Process output,	
Evidence on performed process	
Software/Documentation	[F0055]
Evidence/Reports	[F0056]
How	[C0008]
Guidelines, Checklists,	
Templates	
Guidelines/Templates	[F0052]
Tutorials	[F0065]
enables --> Process	[R0005]
What Results	[C0009]
Metrics	[F0053]
Definition of Done	[F0054]
controls --> Process	[R0006]
Who	[C0010]
Roles,	
Skills, Knowledge,	
Trainings	
Roles + Responsibilities	[F0048]
Knowledge/Skills	[F0049]
enables --> Process	[R0004]
Input	[C0011]
Requirements/Design	[F0057]
Software/Data	[F0058]
is precondition for --> Process	[R0001]



Standards [D0006]

CMMI [C0058]

Automotive SPICE [C0059]  
ISO/IEC 33001:2015 [F0003]

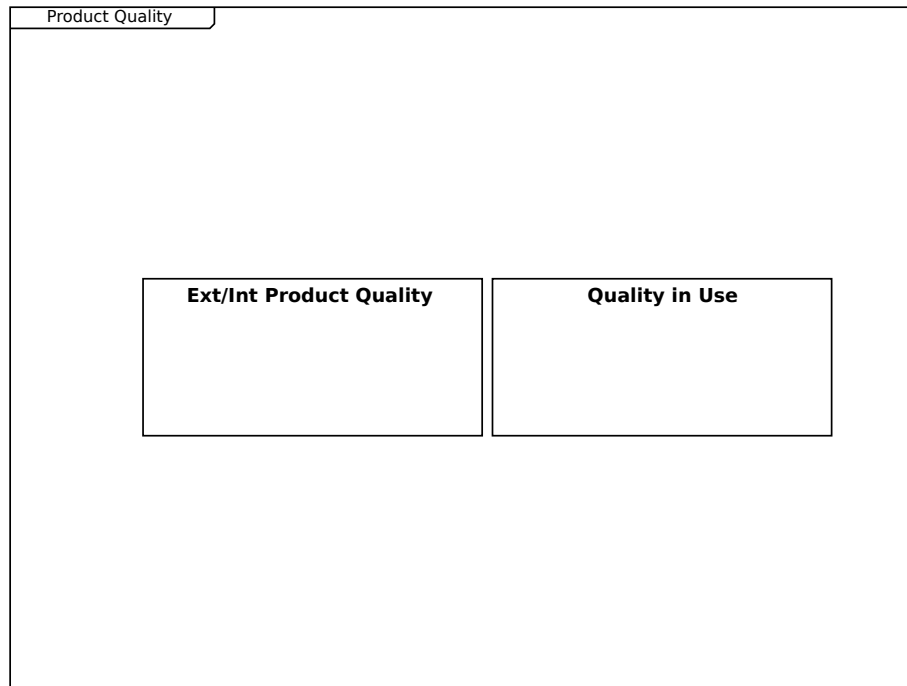
Medical SPICE [C0060]



| The Software Architecture defines the modules, interfaces and relations  
| needed to create the system parts.

Construction	[C0068]
Detailed Design	[F0015]
Source Code + User Doc	[F0016]
Implementation	[F0014]
--> Unit Test	[R0133]
 Software Integration	 [C0069]
Software Integration Test	[F0017]
feeds --> Software Test	[R0047]
 Software Test	 [C0070]
feeds --> System Integration	[R0048]
 System Integration	 [C0071]
System Integration Test	[F0018]
feeds --> System Test	[R0049]
 System Test	 [C0072]
 Unit Test	 [C0117]
feeds --> Software Integration	[R0134]

### 3 Product Quality



Product Quality

[D0002]

Ext/Int Product Quality

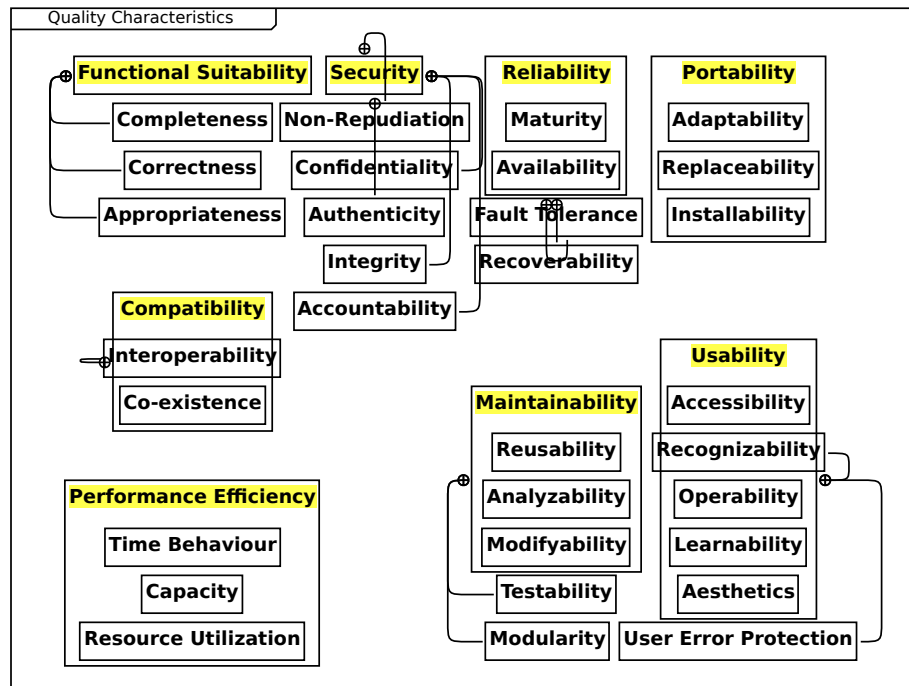
[C0003]

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

Quality in Use

[C0004]

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



Quality Characteristics  
| according to ISO 25010

[D0004]

Maintainability  
--> Testability  
--> Modifiability  
--> Analyzability  
--> Reusability  
--> Modularity

[C0012]  
[R0077]  
[R0078]  
[R0079]  
[R0080]  
[R0081]

Appropriateness

[C0013]

Correctness

[C0014]

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

[C0015]  
[R0056]  
[R0057]  
[R0058]

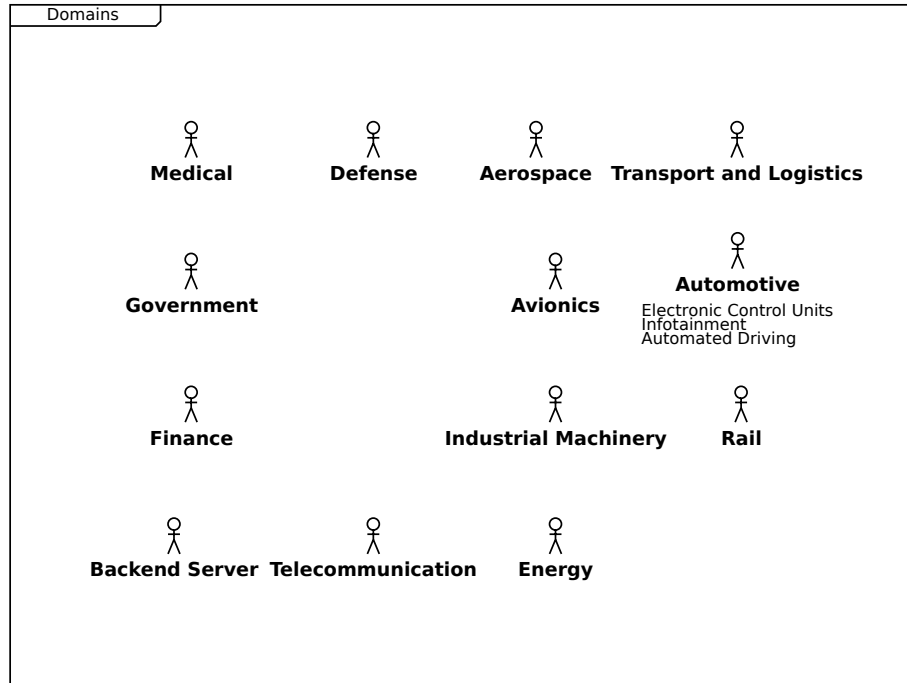


Completeness	[C0016]
Usability	[C0017]
--> Recognizability	[R0071]
--> Learnability	[R0072]
--> Operability	[R0073]
--> User Error Protection	[R0074]
--> Aesthetics	[R0075]
--> Accessibility	[R0076]
Security	[C0018]
--> Authenticity	[R0082]
--> Non-Repudiation	[R0083]
--> Accountability	[R0084]
--> Integrity	[R0085]
--> Confidentiality	[R0086]
Resource Utilization	[C0019]
Portability	[C0020]
--> Adaptability	[R0068]
--> Installability	[R0069]
--> Replaceability	[R0070]
Reliability	[C0021]
--> Maturity	[R0062]
--> Availability	[R0063]
--> Fault Tolerance	[R0064]
--> Recoverability	[R0065]
Compatibility	[C0022]
--> Co-existence	[R0066]
--> Interoperability	[R0067]
Performance Efficiency	[C0023]
--> Time Behaviour	[R0059]
--> Resource Utilization	[R0060]
--> Capacity	[R0061]

Operability	[C0024]
Time Behaviour	[C0025]
Capacity	[C0026]
Co-existence	[C0027]
Interoperability	[C0028]
Accessibility	[C0029]
Recognizability	[C0030]
Aesthetics	[C0031]
Learnability	[C0032]
User Error Protection	[C0033]
Availability	[C0034]
Maturity	[C0035]
Fault Tolerance	[C0036]
Recoverability	[C0037]
Non-Repudiation	[C0038]

Confidentiality	[C0039]
Integrity	[C0040]
Accountability	[C0041]
Authenticity	[C0042]
Modularity	[C0043]
Reusability	[C0044]
Analyzability	[C0045]
Modifyability	[C0046]
Testability	[C0047]
Adaptability	[C0048]
Installability	[C0049]
Replaceability	[C0050]

### 3.1 Product Quality Measures



Domains [D0005]  
 | Measures to improve software quality are sometimes domain-specific.  
 | Some domains are focusing on tests, some on formal proves,  
 | some on reaction times till deploying software updates.

Aerospace [C0051]

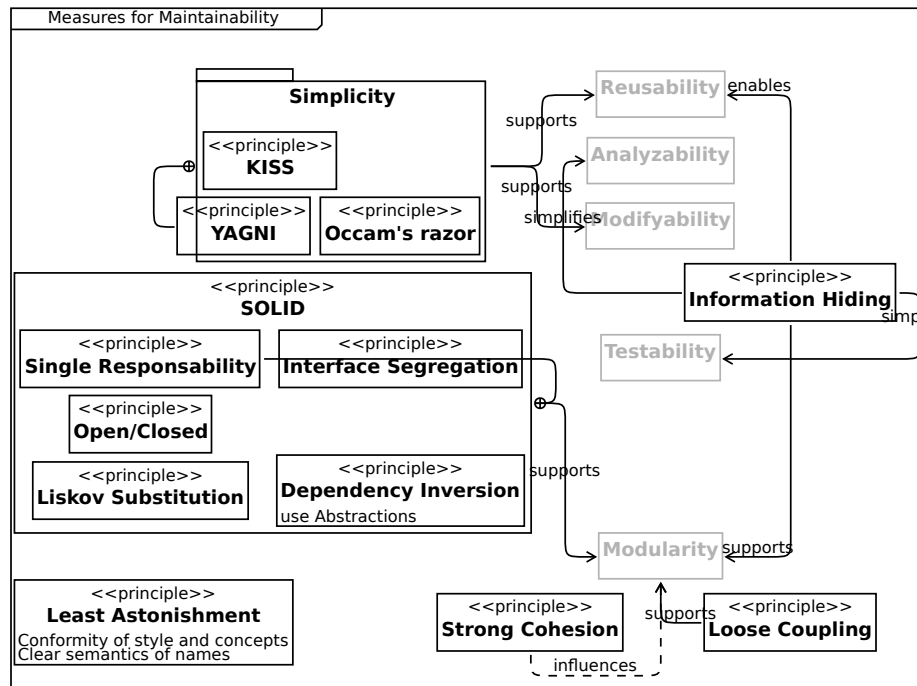
Automotive [C0052]  
 Electronic Control Units [F0001]  
 Infotainment [F0002]  
 Automated Driving [F0047]

Defense [C0053]

Avionics [C0054]

Industrial Machinery [C0055]

Medical	[C0056]
Backend Server	[C0057]
Finance	[C0105]
Telecommunication	[C0106]
Rail	[C0107]
Energy	[C0110]
Transport and Logistics	[C0111]
Government	[C0112]



Measures for Maintainability

[D0007]

Testability

[C0047]

Modifiability

[C0046]

Analyzability

[C0045]

Reusability

[C0044]

Modularity

[C0043]

Single Responsibility

[C0089]

| A software component shall be responsible for one topic only

Open/Closed

[C0090]

| Open for extension, closed for modification

Liskov Substitution [C0091]  
| An implementation of an interface can be replaced  
| by another implementation of the same interface.  
| In object oriented design, types can be replaced by subtypes.

Interface Segregation [C0092]  
| Avoid general purpose interfaces,  
| design multiple interfaces specific to the needs of different users/clients

Dependency Inversion [C0093]  
| A software component shall depend on abstractions, not on concrete implementations  
use Abstractions [F0046]

KISS [C0094]  
| Keep it simple and stupid

YAGNI [C0095]  
| You aren't gonna need it

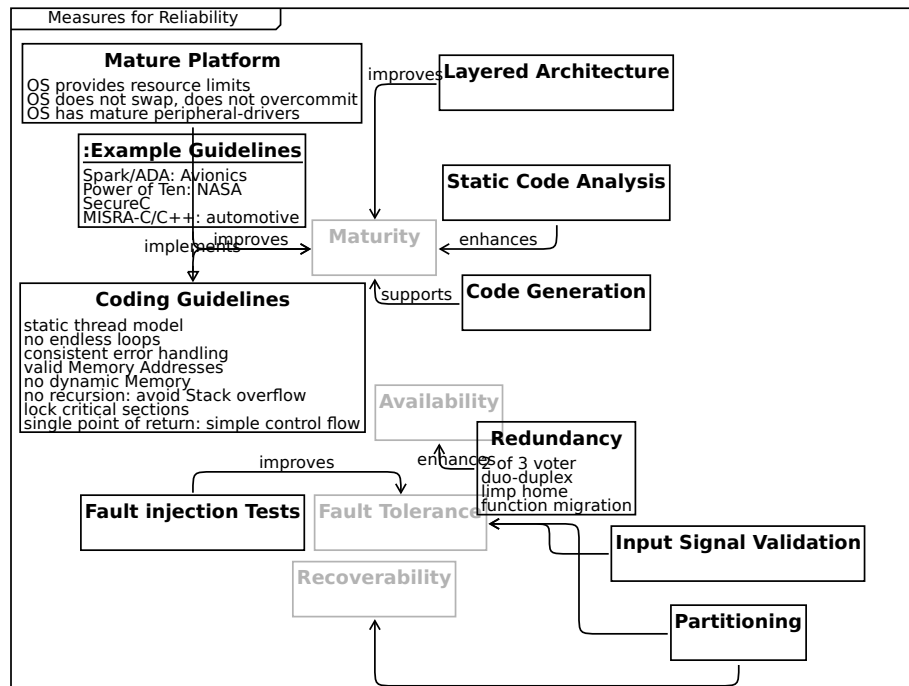
SOLID [C0096]  
--> Interface Segregation [R0101]  
--> Liskov Substitution [R0102]  
--> Dependency Inversion [R0103]  
--> Open/Closed [R0104]  
--> Single Responsibility [R0105]  
supports --> Modularity [R0111]

Occam's razor [C0097]  
| Among competing hypotheses, the one with the fewest assumptions should be selected

Simplicity [C0098]  
--> KISS [R0106]  
--> YAGNI [R0107]  
--> Occam's razor [R0108]  
supports --> Modifiability [R0109]  
supports --> Reusability [R0110]

Loose Coupling	[C0101]
split an entity that consists of multiple loosely coupled parts	
supports --> Modularity	[R0114]
Information Hiding	[C0102]
A software component shall hide its implementation details and	
make information accessible only via defined interfaces	
enables --> Reusability	[R0115]
supports --> Modularity	[R0116]
simplifies --> Testability	[R0117]
simplifies --> Analyzability	[R0118]
Least Astonishment	[C0103]
A reader shall not be surprised when looking at the design.	
Conformity of style and concepts	[F0066]
Clear semantics of names	[F0067]
Module names, Interface names, Message names, Port names:	
The name shall state what the data/function represents.	
The name shall be short and as concrete as possible.	
Strong Cohesion	[C0104]
influences --> Modularity	[R0119]





Measures for Reliability

[D0008]

Recoverability

[C0037]

Fault Tolerance

[C0036]

Availability

[C0034]

Maturity

[C0035]

Layered Architecture  
improves --> Maturity

[C0061]

[R0039]

Coding Guidelines

[C0062]

| Coding guidelines define how to get reproducible behavior of software.

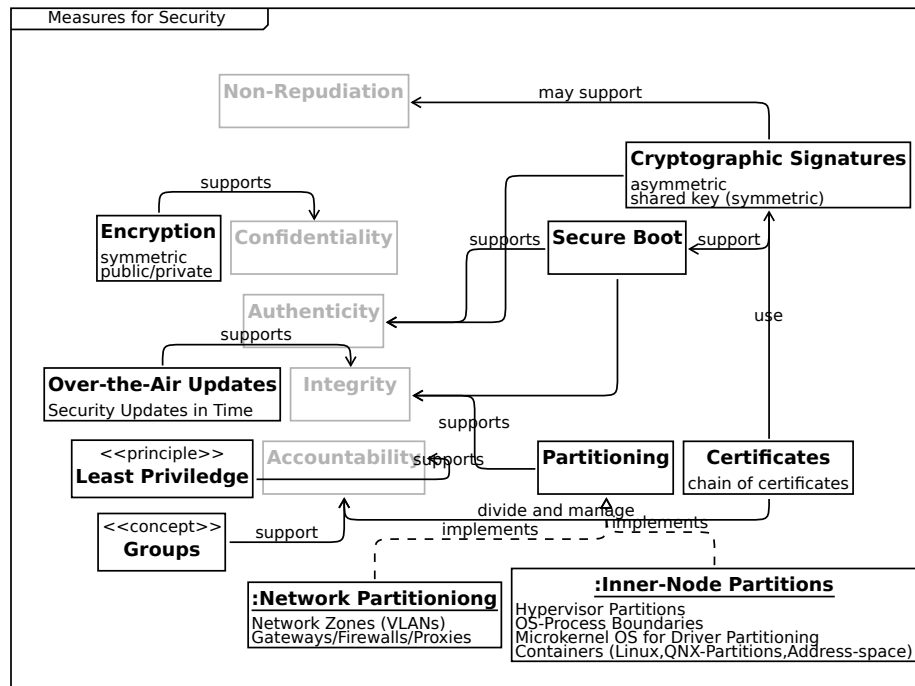
| Managing system resources is a key factor.

static thread model

[F0010]

Execution threads shall not be started/stopped dynamically	
no endless loops	[F0008]
Every loop shall have a counter to ensures that	
after a predefined maximum value the loop is definitely quit	
consistent error handling	[F0009]
Inconsistencies in error handling make	
bugs in error handling more likely	
valid Memory Addresses	[F0007]
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	[F0006]
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	[F0005]
lock critical sections	[F0024]
Always lock critical sections.	
Exceptions to locking are a nightmare.	
single point of return: simple control flow	[F0023]
Simple control flow is key to understandable code	
improves --> Maturity	[R0040]
 Fault injection Tests	[C0063]
improves --> Fault Tolerance	[R0041]
 Example Guidelines	[C0073]
Spark/ADA: Avionics	[F0022]
Power of Ten: NASA	[F0019]
SecureC	[F0021]
MISRA-C/C++: automotive	[F0020]
implements --> Coding Guidelines	[R0054]
 Redundancy	[C0074]
2 of 3 voter	[F0025]
duo-duplex	[F0026]
limp home	[F0027]
function migration	[F0028]
enhances --> Availability	[R0055]

Static Code Analysis	[C0086]
enhances --> Maturity	[R0099]
 Code Generation	 [C0087]
An understandable model and a small code generator	
allow to generate mature software.	
supports --> Maturity	[R0100]
 Mature Platform	 [C0109]
OS provides resource limits	[F0061]
OS does not swap, does not overcommit	[F0062]
OS has mature peripheral-drivers	[F0063]
--> Maturity	[R0124]
 Input Signal Validation	 [C0083]
--> Fault Tolerance	[R0128]
 Partitioning	 [C0075]
--> Fault Tolerance	[R0129]
--> Recoverability	[R0130]



Measures for Security [D0010]  
 | 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.

Confidentiality [C0039]

Integrity [C0040]

Authenticity [C0042]

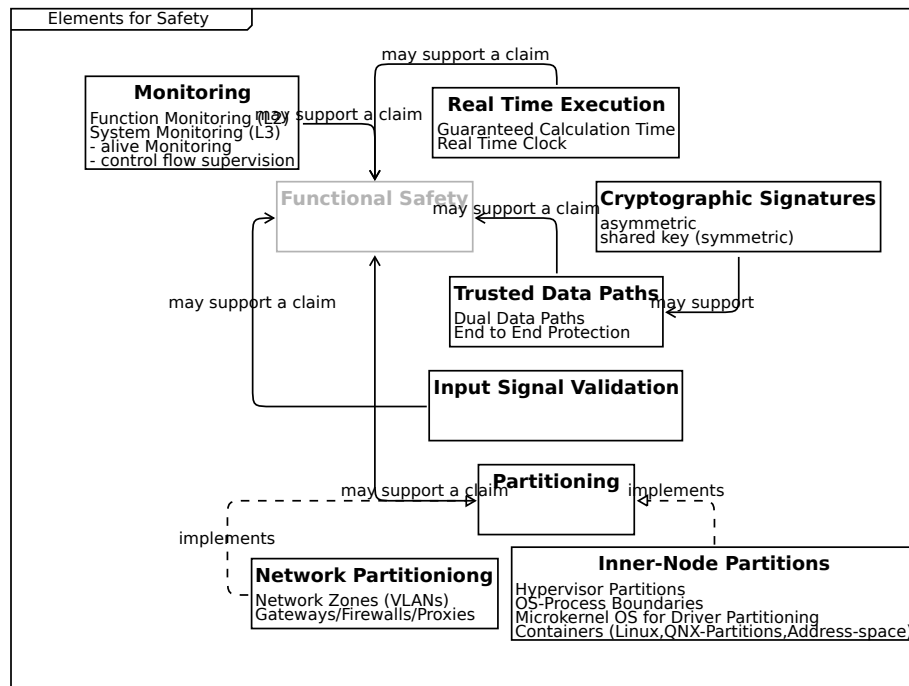
Partitioning [C0075]  
 supports --> Integrity [R0089]

Network Partitioning [C0076]  
 Network Zones (VLANs) [F0029]

Gateways/Firewalls/Proxies	[F0030]
implements --> Partitioning	[R0087]
Inner-Node Partitions	[C0077]
Hypervisor Partitions	[F0031]
OS-Process Boundaries	[F0032]
Microkernel OS for Driver Partitioning	[F0033]
Containers (Linux,QNX-Partitions,Address-space)	[F0034]
implements --> Partitioning	[R0088]
Over-the-Air Updates	[C0078]
Security Updates in Time	[F0035]
supports --> Integrity	[R0090]
Cryptographic Signatures	[C0079]
asymmetric	[F0038]
shared key (symmetric)	[F0039]
supports --> Authenticity	[R0091]
may support --> Non-Repudiation	[R0120]
support --> Secure Boot	[R0123]
Encryption	[C0080]
symmetric	[F0036]
public/private	[F0037]
supports --> Confidentiality	[R0092]
Least Privilege	[C0099]
Entities shall have only the access rights they need for their purpose	
supports --> Accountability	[R0112]
Non-Repudiation	[C0038]
Accountability	[C0041]
Secure Boot	[C0108]
--> Integrity	[R0121]
--> Authenticity	[R0122]

Groups [C0113]  
 | Grouping Clients/Actors helps  
 | Grouping Services  
 | helps in administration of access rights  
 support --> Accountability [R0125]

Certificates [C0114]  
 chain of certificates [F0064]  
 use --> Cryptographic Signatures [R0126]  
 divide and manage --> Accountability [R0127]



Elements for Safety [D0011]

Functional Safety [C0081]

Monitoring [C0084]  
 Function Monitoring (L2) [F0040]  
 System Monitoring (L3) [F0041]  
 - alive Monitoring [F0059]  
 - control flow supervision [F0060]

may support a claim --> Functional Safety	[R0093]
Input Signal Validation	[C0083]
may support a claim --> Functional Safety	[R0095]
Real Time Execution	[C0085]
Guaranteed Calculation Time	[F0044]
Real Time Clock	[F0045]
may support a claim --> Functional Safety	[R0098]
Trusted Data Paths	[C0082]
Dual Data Paths	[F0042]
End to End Protection	[F0043]
may support a claim --> Functional Safety	[R0094]
Cryptographic Signatures	[C0079]
asymmetric	[F0038]
shared key (symmetric)	[F0039]
may support --> Trusted Data Paths	[R0097]
Partitioning	[C0075]
may support a claim --> Functional Safety	[R0096]
Inner-Node Partitions	[C0077]
Hypervisor Partitions	[F0031]
OS-Process Boundaries	[F0032]
Microkernel OS for Driver Partitioning	[F0033]
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