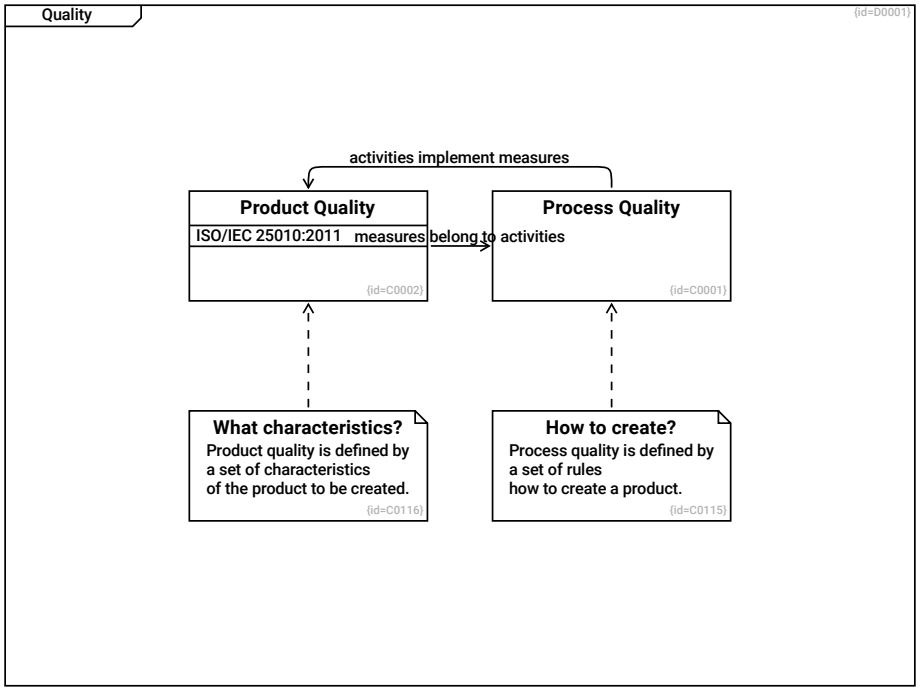
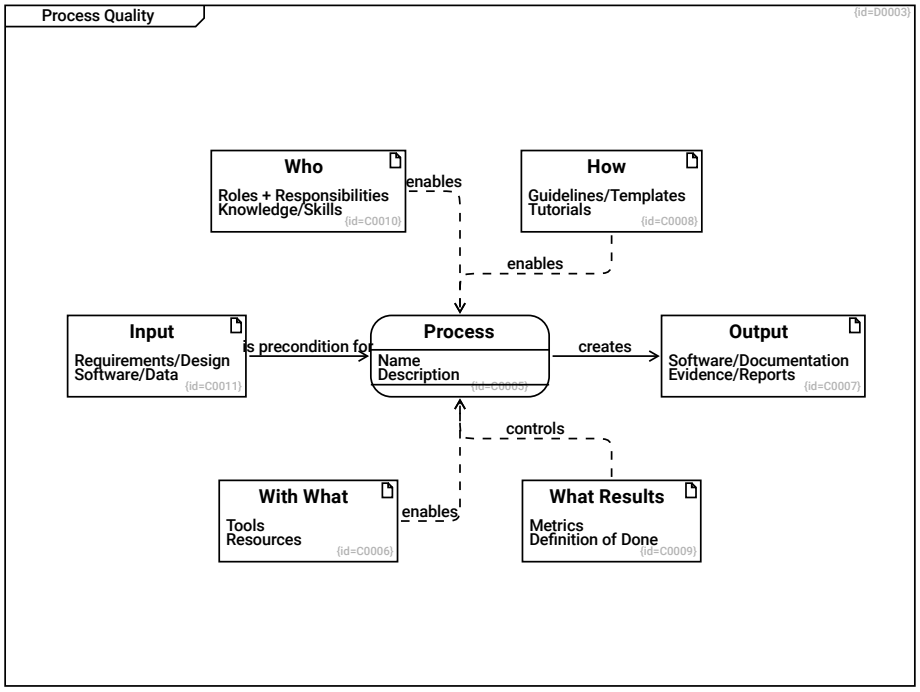
1 Quality Example




```
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.
  activities implement measures --> Product Quality [R0138]


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]
  measures belong to activities --> Process Quality [R0137]


How to create?                                           [C0115]
| Process quality is defined by
| a set of rules
```

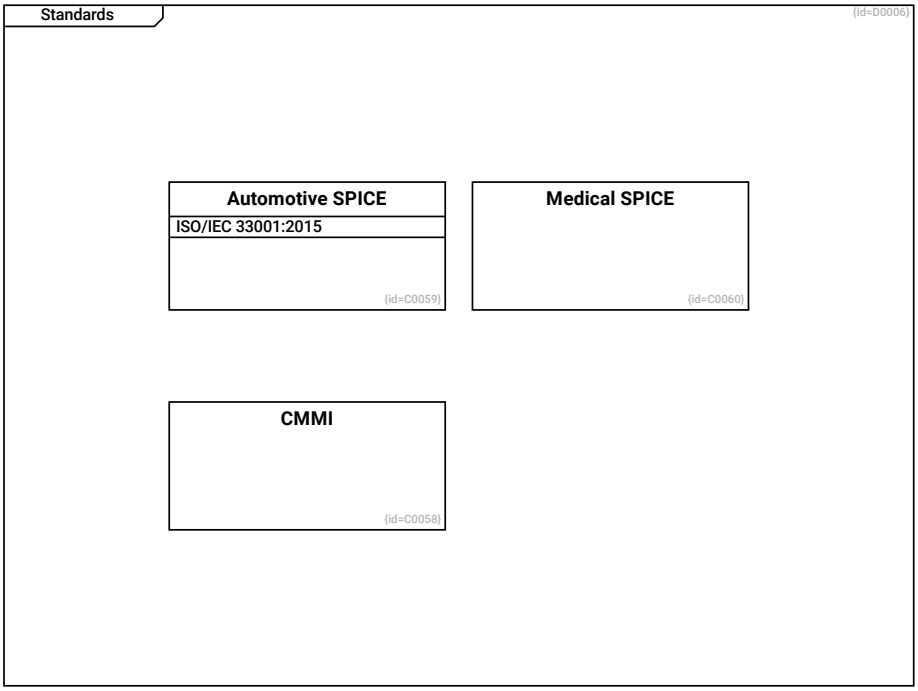
```
| how to create a product.
  --> Process Quality                                   [R0131]


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]
```

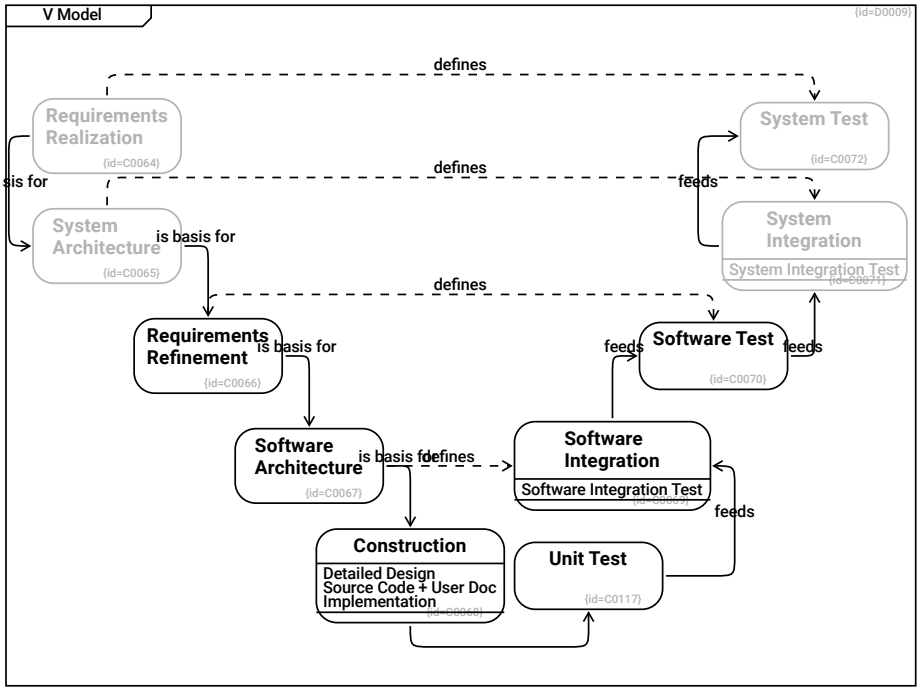


Standards [D0006]

CMMI [C0058]

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

Medical SPICE [C0060]



V Model [D0009]

Requirements Realization [C0064]
  is basis for --> System Architecture [R0042]
  defines --> System Test [R0050]

System Architecture [C0065]
  is basis for --> Requirements Refinement [R0043]
  defines --> System Integration [R0051]

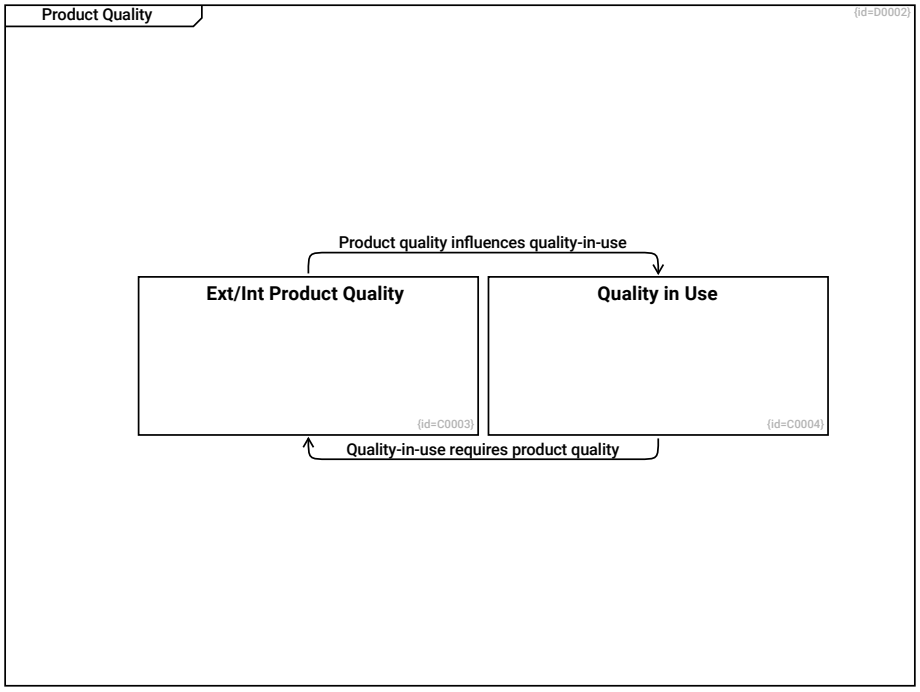
Requirements Refinement [C0066]
  is basis for --> Software Architecture [R0044]
  defines --> Software Test [R0052]

Software Architecture [C0067]
  defines --> Software Integration [R0053]
  | The Software Architecture defines the modules, interfaces and relations
  | needed to integrate and test the system.
  is basis for --> Construction [R0045]

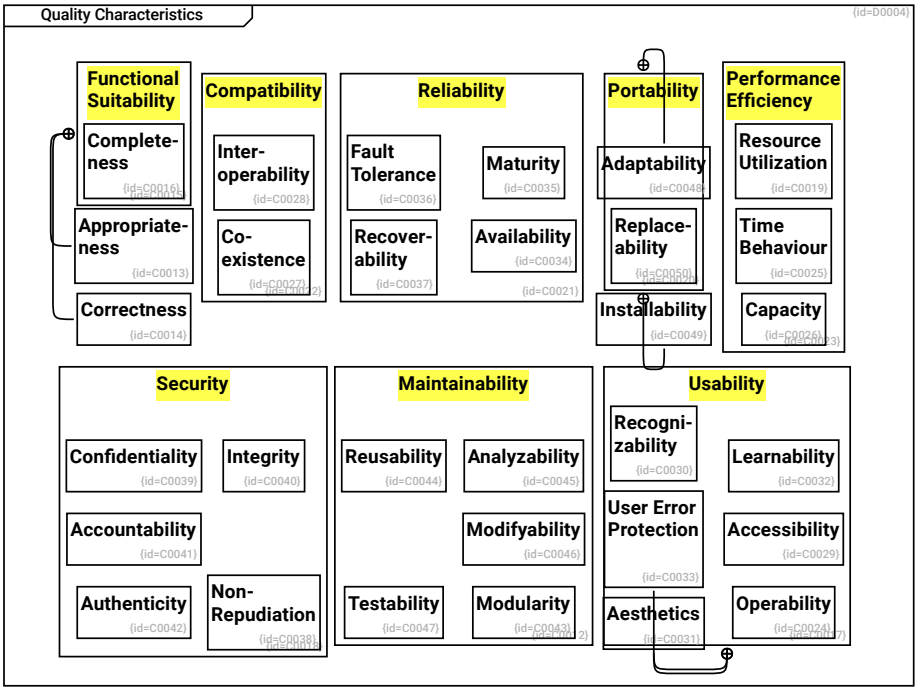
| The Software Architecture defines the modules, interfaces and relations
| needed to create the system parts.

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.
  Product quality influences quality-in-use --> Quality in Use [R0139]


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-in-use requires product quality --> Ext/Int Product Quality  [R0140]
```



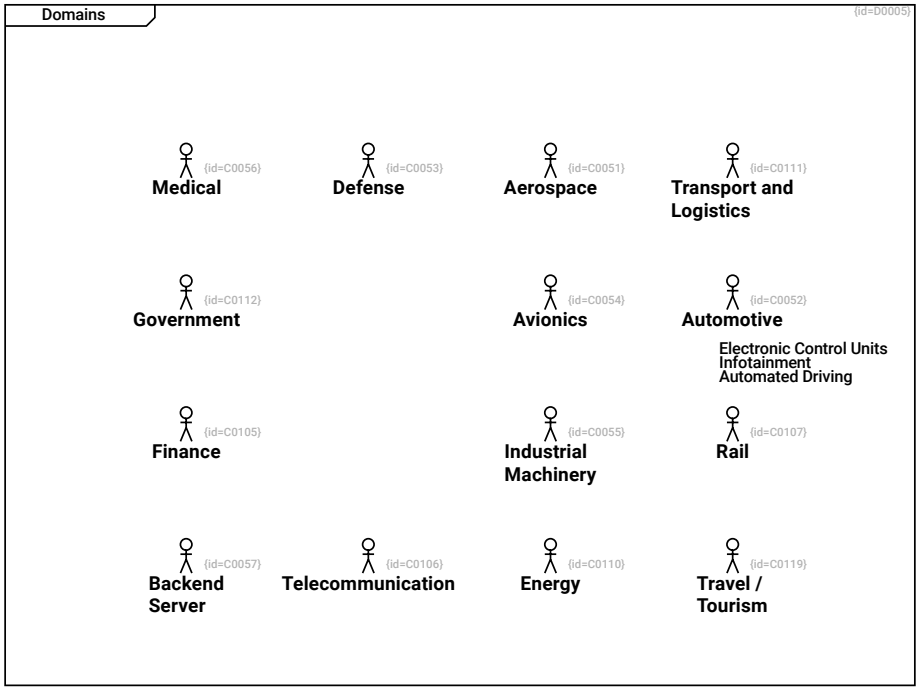

```
Quality Characteristics                          [D0004]
| Charactersitics of Ext/Int Product Quality
| according to ISO 25010


Maintainability                                  [C0012]
  --> Testability                                [R0077]
  --> Modifyability                              [R0078]
  --> Analyzability                              [R0079]
  --> Reusability                                [R0080]
  --> Modularity                                 [R0081]


Correctness                                      [C0014]


Functional Suitability                           [C0015]
  --> Complete-ness                              [R0056]
  --> Correctness                                [R0057]
  --> Appropriate-ness                           [R0058]


Complete-ness                                    [C0016]
```

```
Usability                                   [C0017]
  --> Recogni-zability                      [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]
  --> Replace-ability                       [R0070]


Reliability                                 [C0021]
  --> Maturity                              [R0062]
  --> Availability                          [R0063]
  --> Fault Tolerance                       [R0064]
  --> Recover-ability                       [R0065]


Compatibility                               [C0022]
  --> Co-existence                          [R0066]
  --> Inter-operability                     [R0067]


Performance Efficiency                      [C0023]
  --> Time Behaviour                        [R0059]
  --> Resource Utilization                  [R0060]
  --> Capacity                              [R0061]
```

Operability	[C0024]
Time Behaviour	[C0025]
Capacity	[C0026]
Co-existence	[C0027]
Inter-operability	[C0028]
Accessibility	[C0029]
Recogni-zability	[C0030]
Aesthetics	[C0031]
Learnability	[C0032]
User Error Protection	[C0033]
Availability	[C0034]
Maturity	[C0035]
Fault Tolerance	[C0036]
Recover-ability	[C0037]
Non-Repudiation	[C0038]
Confidentiality	[C0039]

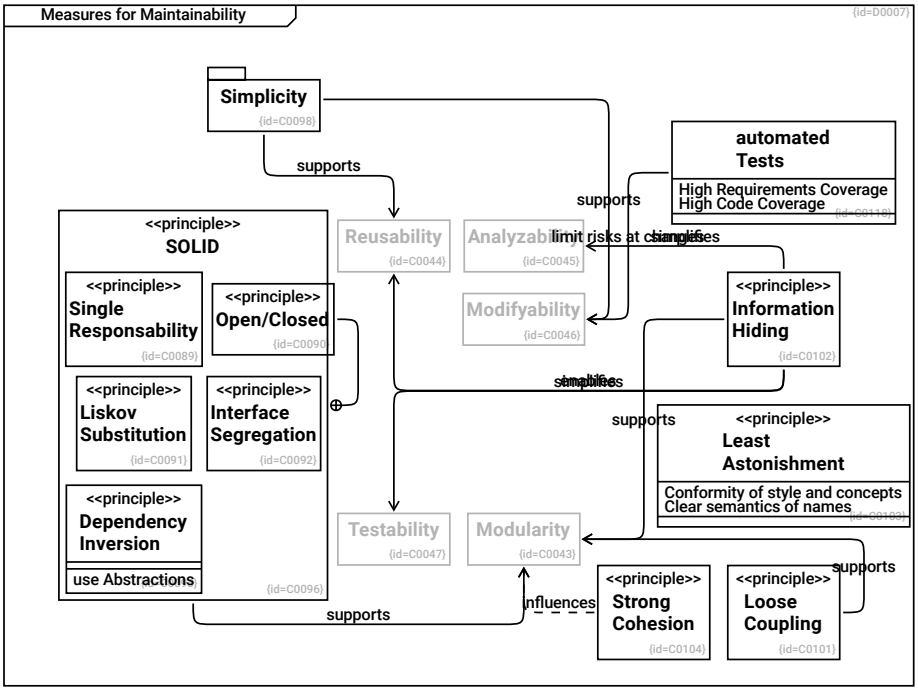
Integrity	[C0040]
Accountability	[C0041]
Authenticity	[C0042]
Modularity	[C0043]
Reusability	[C0044]
Analyzability	[C0045]
Testability	[C0047]
Adaptability	[C0048]
Installability	[C0049]
Replace-ability	[C0050]
Appropriate-ness	[C0013]
Modifyability	[C0046]

3.1 Product Quality Measures




```
Domains                                              [D0005]
| The "Quality in Use" depends on the domain.
| Measures to improve software quality are often domain-specific.
| Some domains are more 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]
Travel / Tourism	[C0119]



Measures for Maintainability [D0007]
| This diagram shows examples - not aiming for completeness.

Testability [C0047]

Analyzability [C0045]

Reusability [C0044]

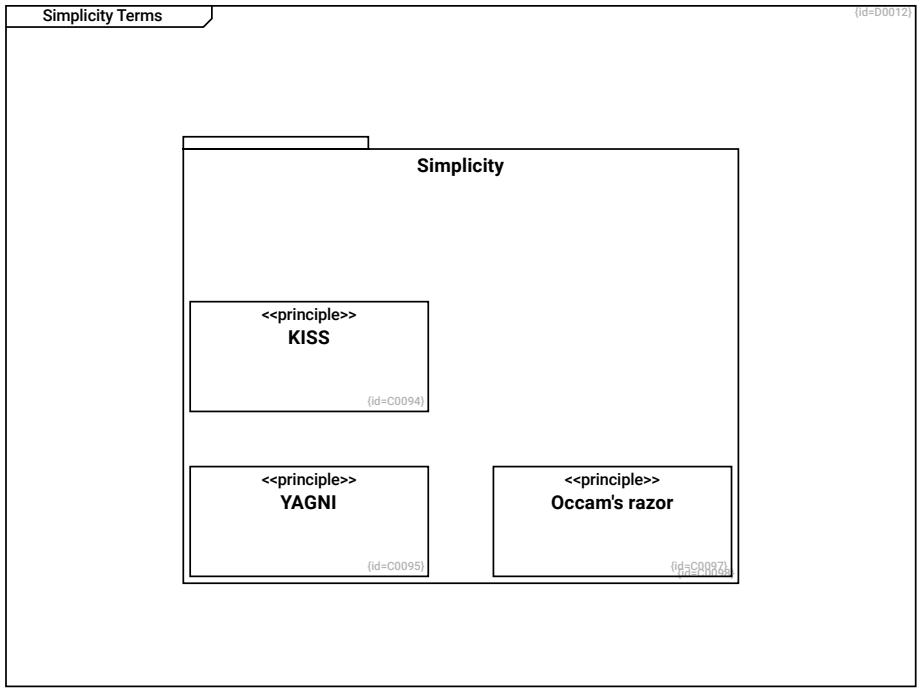
Modularity [C0043]

Single Responsability [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]


Simplicity                                         [C0098]
  supports --> Modifyability                       [R0109]
  supports --> Reusability                         [R0110]


Loose Coupling                                     [C0101]
| split an entity that consists of multiple loosely coupled parts
  supports --> Modularity                          [R0114]


Information Hiding                                 [C0102]
| A sofware 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]


Strong Cohesion                                    [C0104]
  influences --> Modularity                        [R0119]


automated Tests                                    [C0118]
  High Requirements Coverage                       [F0069]
  High Code Coverage                               [F0068]
  limit risks at changes --> Modifyability         [R0135]
```

```
Modifyability                                   [C0046]


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


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.
```



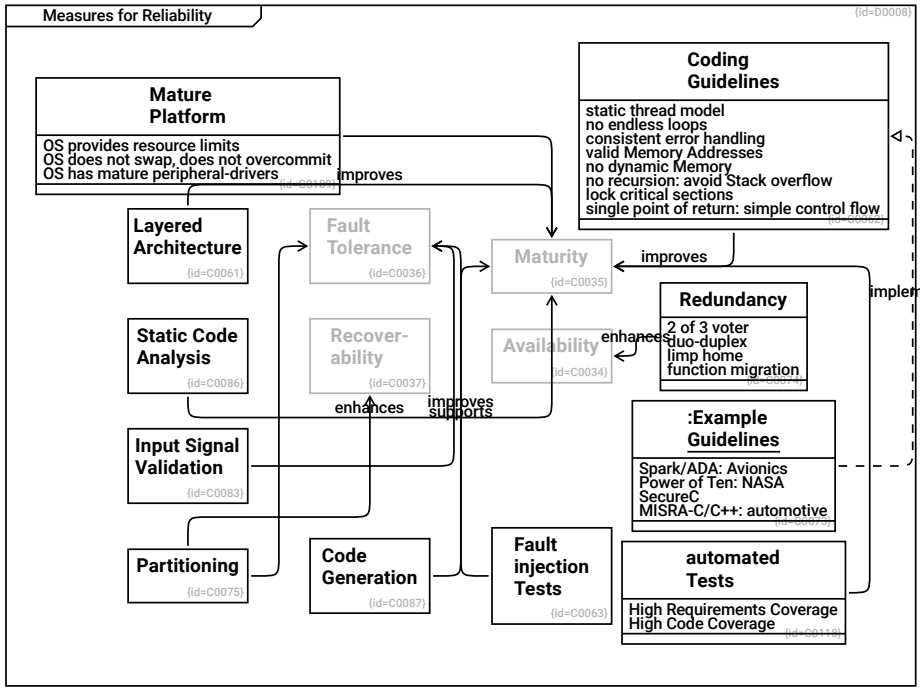

```
Simplicity Terms                                [D0012]


Simplicity                                      [C0098]
```

--> KISS [R0106]
--> YAGNI [R0107]
--> Occam's razor [R0108]

KISS [C0094]
| Keep it simple and stupid

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

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



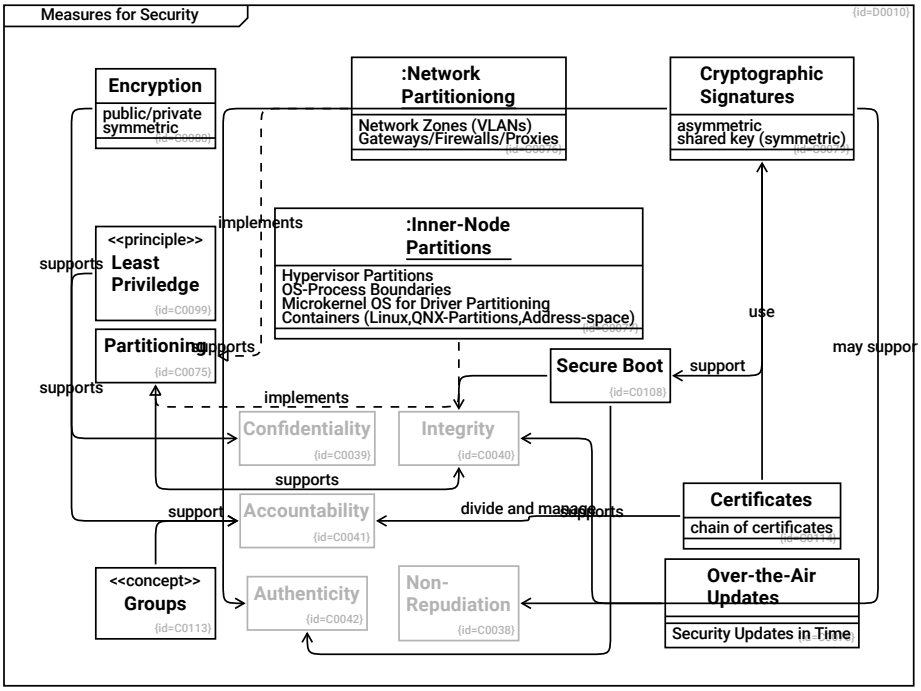
Measures for Reliability [D0008]
| This diagram shows examples - not aiming for completeness.

Recover-ability [C0037]

Fault Tolerance [C0036]

```
Availability                                    [C0034]


Maturity                                        [C0035]


Layered Architecture                            [C0061]
  improves --> Maturity                         [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]
```

```
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]
  --> Recover-ability                               [R0130]


automated Tests                                     [C0118]
  High Requirements Coverage                        [F0069]
  High Code Coverage                                [F0068]
  --> Maturity                                      [R0136]


Example Guidelines                                  [C0073]
  Spark/ADA: Avionics                               [F0022]
  Power of Ten: NASA                                [F0019]
  SecureC                                           [F0021]
  MISRA-C/C++: automotive                           [F0020]
  implements --> Coding Guidelines                  [R0054]
```

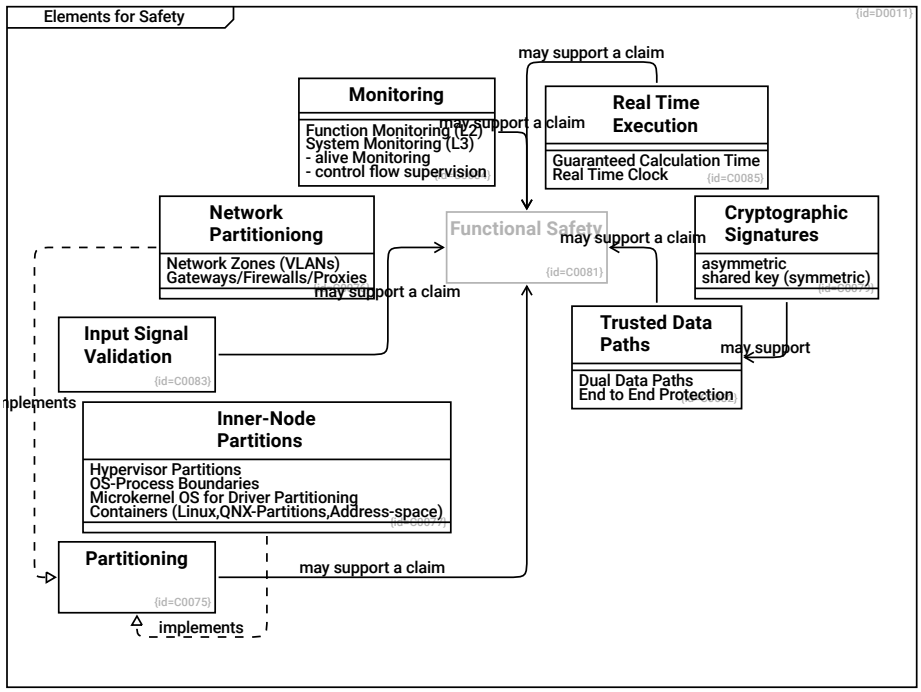



```
Measures for Security                                   [D0010]
| Functional safety and security are different goals
| but have common mechanisms to support these.
|
| The diagram is not meant to be complete,
| it just shows that technical mechanisms support quality goals.


Confidentiality                                         [C0039]


Integrity                                               [C0040]


Authenticity                                            [C0042]


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


Network Partitioniong                                   [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]
  public/private                                      [F0037]
  symmetric                                           [F0036]
  supports --> Confidentiality                        [R0092]


Least Priviledge                                      [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/Users and
| 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]
| This diagram shows examples - not aiming for completeness.

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]
  Containers (Linux,QNX-Partitions,Address-space)     [F0034]
  implements --> Partitioning                         [R0088]


Network Partitioniong                                 [C0076]
  Network Zones (VLANs)                               [F0029]
  Gateways/Firewalls/Proxies                          [F0030]
  implements --> Partitioning                         [R0087]
```