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ECSS
FOR SPACE STANDARDIZATION

ECSS-Q-ST-80C

Space product assurance

Software product assurance

Training Course

Presenters (all of them from TEC-QQS):

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ECSS-Q-ST-80C

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ECSS-Q-ST-80C

- **Origins and Status**
- **Key Concepts**
- **Organization**
  - Software Product Program Implementation
  - Software Process Assurance
  - Software Product Quality Assurance
- **Handbooks**

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Origins and Status of the ECSS-Q-ST-80 Standard

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Software Product Assurance

Software Product Assurance (SPA)

3.2.23

- *the totality of activities, standards, controls and procedures in the lifetime of a software product which establish confidence that the delivered software product, or software affecting the quality of the delivered product, conforms to customer requirements*

Objectives:

provide adequate confidence to the customer and to the suppliers that developed or reused software satisfies the requirements throughout the system lifetime

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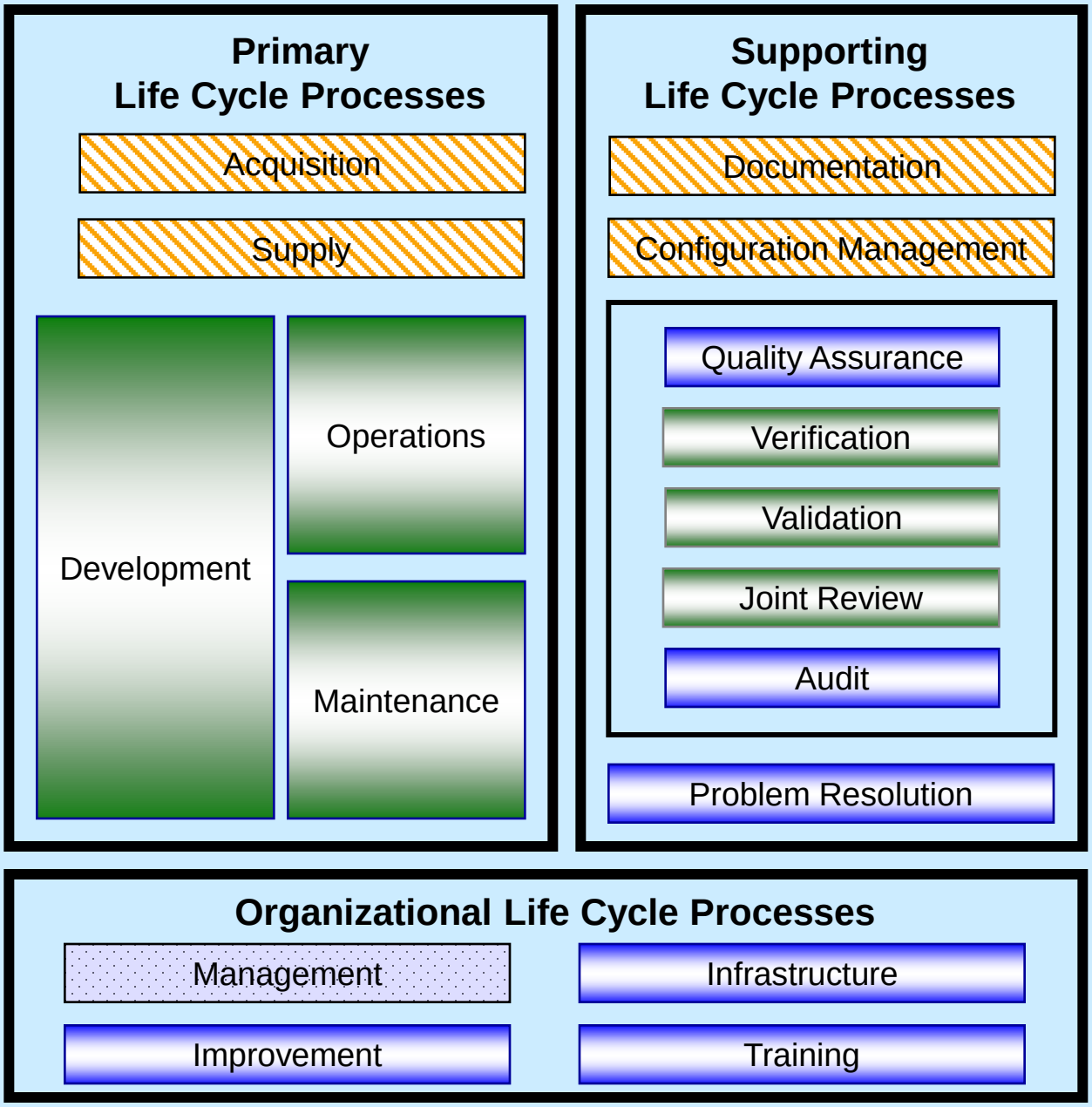
Based on ISO/IEC 12207



Other ECSS

E-40C

Q-80C

Details for SPA and/or SWE

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Evolution of ECSS-Q-80

- **ECSS-Q-80A** **April 1996**
  First Issue
  - *Contains several engineering requirements*
- **ECSS-Q-80B** **October 2003**
  Second Issue
  - *Updated and harmonized with ECSS-E-40B*
- **ECSS-Q-ST-80C** **March 2009**
  Current Issue
  - *Updated and streamlined in accordance with ECSS Task Force 2 recommendations*

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Key Concepts in the ECSS-Q-ST-80 Standard

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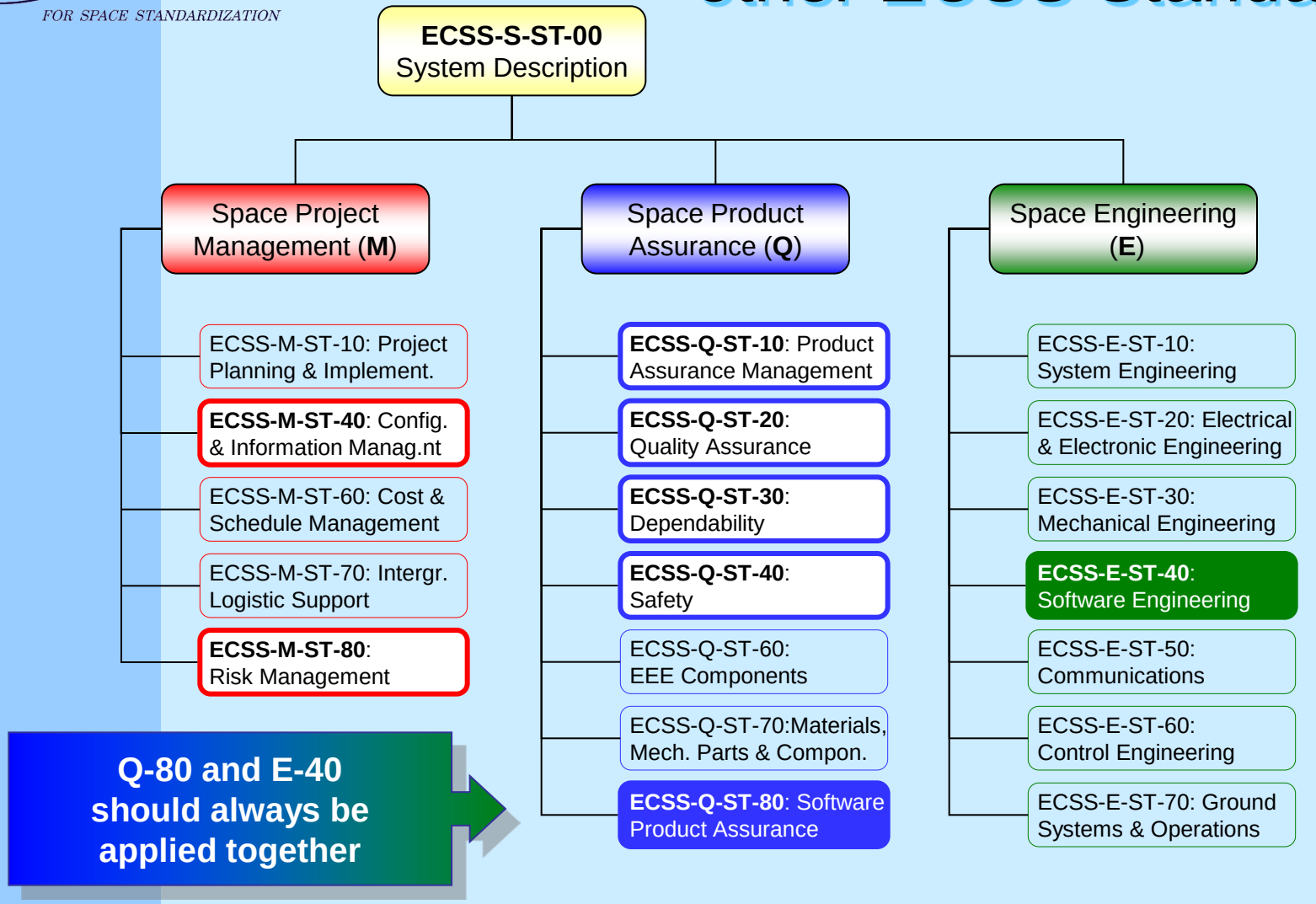
The relation to the other ECSS Standards



Q-80 and E-40 should always be applied together

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The customer-supplier relationship

- **Described in ECSS-S-ST-00 (6.1)**
- **Applied recursively (customer-supplier chain)**
  - Top level customer (typically an Agency, e.g. ESA)
  - Intermediate levels: *both customer and supplier*
  - Lowest level: supplier only

Customer

Supplier

- **For software development, the customer is often internal**
  - "System level"

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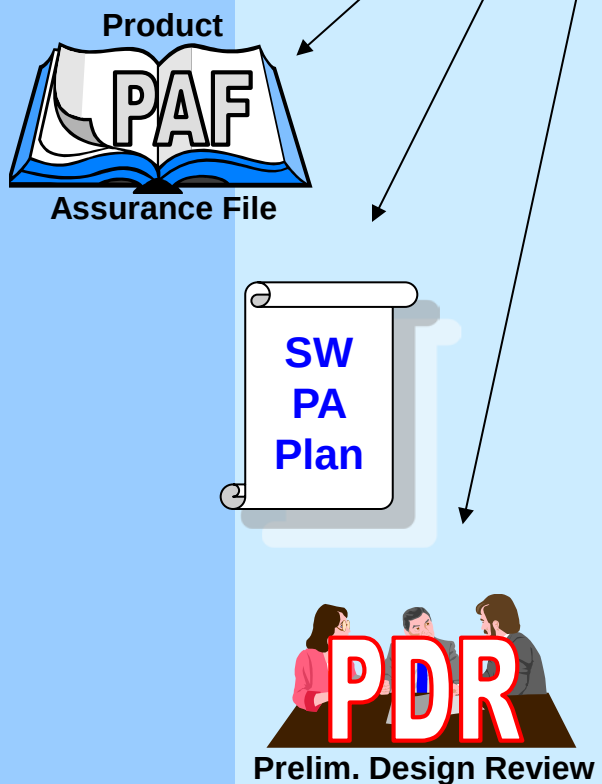
Requirements & Expected Output

EXPECTED OUTPUT: *Software product assurance plan [PAF, SPAP; PDR].*



- **Each Q-80C requirement is identified by a hierarchical number**
- **For each requirement, the associated Expected Output is specified**
- **The Expected Output includes:**
  - the **destination file**
  - the **DRD** of the document containing the output
  - the **reviews** at which the output must be provided

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Software documentation

Annex A

RB — Requirements Baseline

TS — Technical Specification

DDF — Design Definition File

Design DJF — Justification File

MGT — Management File

OP — Operational Documentation

MF — Maintenance File

Files (a.k.a. folders) are shared with ECSS-E-ST-40

Product PAF — Assurance File

- SW PA Plan — DRD — **Annex B**
- SW PA Milestone Report — DRD — **Annex C**
- SW PA Req.ments for Subco's
- …

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The concept of tailoring

- **ECSS Standards should not be made applicable "as is" ⇒ tailoring required**
- **Tailoring is a customer's responsibility**
- **ECSS-Q-ST-80C contains a tailoring matrix based on software criticality**

Annex D

Requirements applicable to ECSS-E-ST-40 processes that are tailored out are automatically not applicable

SW Product Q-80C Assurance

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Organization of the ECSS-Q-ST-80 Standard

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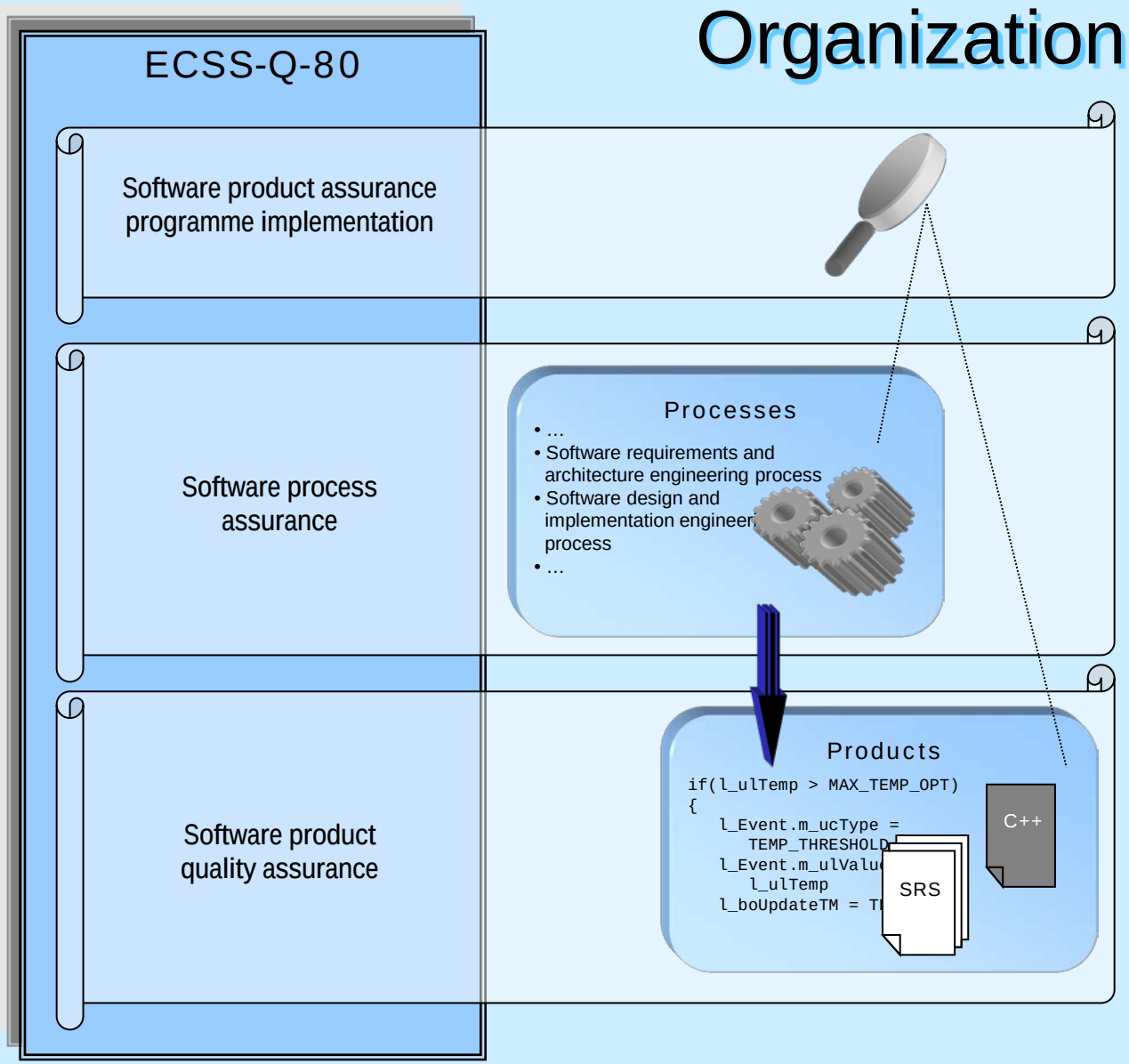
Organization

Clause 5

Clause 6

Clause 7



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Structure

Software product assurance programme implementation

5.1 Organization and responsibility
5.2 Software product assurance programme management
5.3 Risk management and critical item control
5.4 Supplier selection and control
5.5 Procurement
5.6 Tools and supporting environment
5.7 Assessment and improvement process

Software process assurance

6.1 Software development life cycle
6.2 Requirements applicable to all software engineering processes
6.3 Requirements applicable to individual software engineering processes or activities

Software product quality assurance

7.1 Product quality objectives and metrication
7.2 Product quality requirements
7.3 Software intended for reuse
7.4 Standard ground hardware and services for operational system
7.5 Firmware

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Software Product Assurance Programme Implementation

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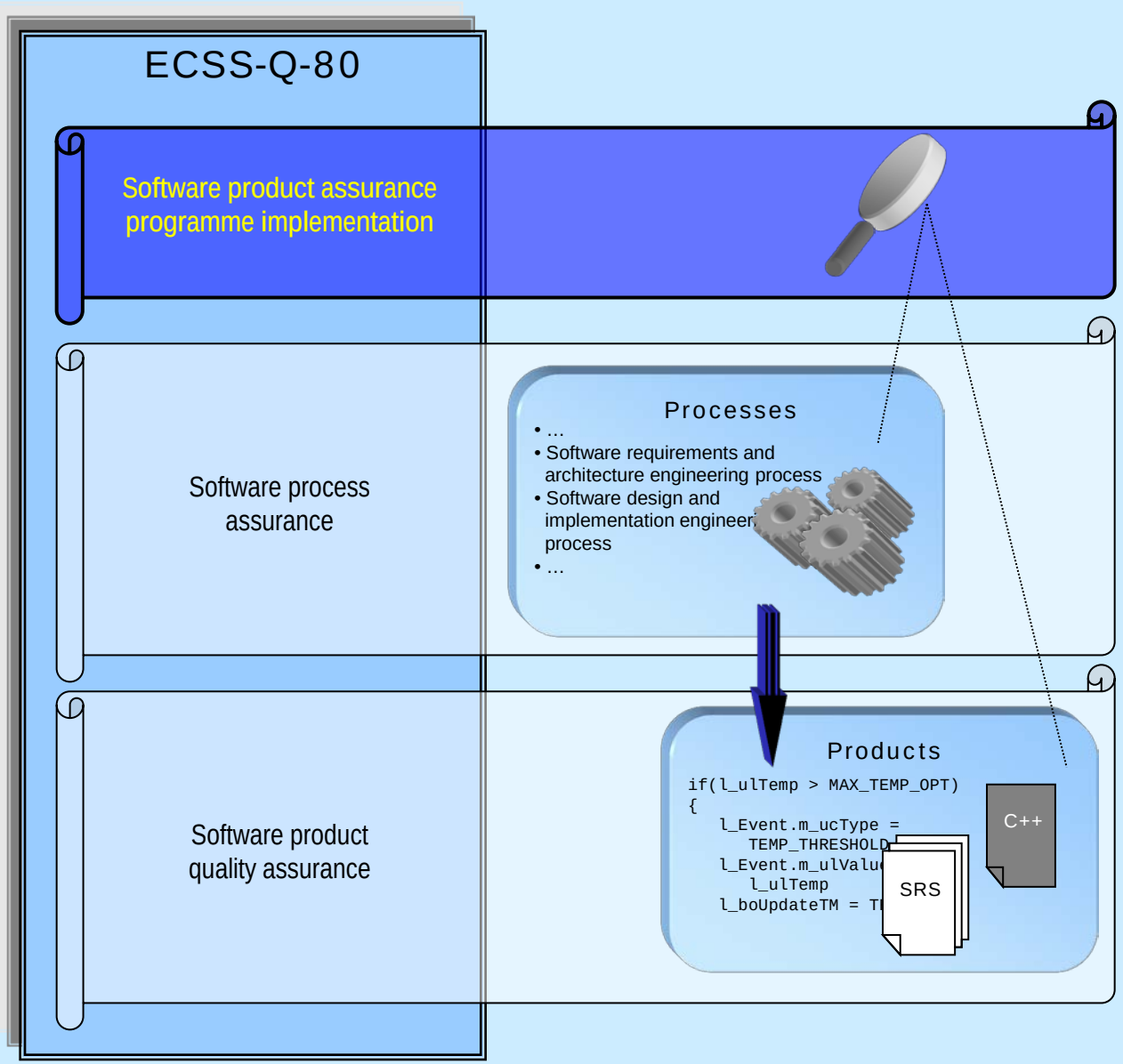
Clause 5

Setting up and running a SW PA programme



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Organization and Responsibility

Software product assurance programme implementation

5.1 Organization and responsibility
5.2 Software product assurance programme management
5.3 Risk management and critical item co
5.4 Supplier selection and control
5.5 Procurement
5.6 Tools and supporting environment
5.7 Assessment and improvement

- 5.1.1 Organization
- 5.1.2 Responsibility and authority
- 5.1.3 Resources
- 5.1.4 Software product assurance manager/engineer
- 5.1.5 Training

Software p

6.1 Softwar
6.2 Require
6.3 Requirements applicable to individual software engineering processes or activities

Software product quality assurance

7.1 Product quality objectives and metrication
7.2 Product quality requirements
7.3 Software intended for reuse
7.4 Standard ground hardware and services for operational system
7.5 Firmware

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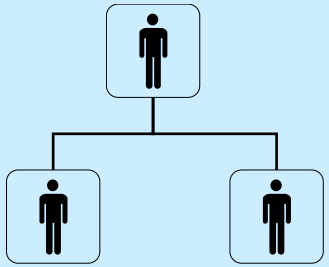
Organization and Responsibility

5.1.1

- **An organizational structure for software development must be defined**

5.1.2

- **For personnel whose work affects quality:**
  - Roles
  - Responsibilities
  - Authority
  - Interrelations
  - Interfaces to other organizations (internal and external)
  - Delegation of PA tasks to lower-level suppliers



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Resources

5.1.3

- **The supplier must identify resource requirements for the software product assurance function**
- **Resources must be allocated and made available for the SPA tasks**
- **The independence of personnel performing reviews and audits must be ensured**
  - Not involved in the processes being reviewed/audited

Reflects ECSS-Q-ST-10C, subclause 5.1.1.3

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Software Product Assurance Manager/Engineer

5.1.4

- **The supplier must identify the personnel in charge of the software product assurance tasks**
- **The traditional title of software product assurance manager may not be applicable ⇒ engineer**
- **He/she:**
  - Reports to Project Manager (via PA manager, if any)
  - Has got authority and independence to carry out his/her tasks
  - Has got unimpeded access to higher management

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Training

5.1.5

- **The supplier must timely plan to ensure that:**
  - the resources and skills needed for all the staff are acquired or developed
  - the right composition and categories of appropriately trained personnel are available
- **The training subjects must be determined by the specific tools, techniques, methodologies and computer resources to be used**
- **A training plan must be produced and training records must be maintained**

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Software product assurance programme management

Software product assurance programme implementation

5.1 Organization and responsibility
5.2 Software product assurance programme management
5.3 Risk management and critical item control
5.4 Supplier selection and control
5.5 Procurement
5.6 Tools and supporting environment
5.7 Assessment and improvement process

5.2.1 Software product assurance planning and control
5.2.2 Software product assurance reporting
5.2.3 Audits
5.2.4 Alerts
5.2.5 Software problems
5.2.6 Nonconformances
5.2.7 Quality requirements and quality models

Software p

6.1 Softwar
6.2 Require
6.3 Require
or activ

Software p

7.1 Product quality objectives and metrication
7.2 Product quality requirements
7.3 Software intended for reuse
7.4 Standard ground hardware and services for operational system
7.5 Firmware

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Software product assurance planning and control

5.2.1

- **A Software Product Assurance Plan must be produced and delivered for customer approval**
  - May be part of the overall project PA plan
- **The SPAP must be up-to-date at each milestone**
- **The SPAP must contain a compliance matrix with respect to the applicable requirements**
  - For each requirement, reference to the implementation of that requirement

Annex B

- **A DRD for the SPAP is provided in Annex B**

Expected Output

Software product assurance plan [PAF, SPAP SRR, PDR].

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Software product assurance reporting

5.2.2

Annex C

- **Regular software product assurance reporting to be provided as part of the overall project reporting**
- **Specific software product assurance milestone reporting to be provided at milestone reviews**
- **Main reporting subjects:**
  - Assessment of product and process quality
  - Verifications undertaken
  - Problems detected and resolved

Expected Output

Software product assurance milestone report [PAF, SPAMR SRR, PDR, CDR, QR, AR, ORR].

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Audits and Alerts

5.2.3

- **Audits to be performed in accordance with ECSS-Q-ST-10, subclause 5.2.3**
  - Internal and external (on suppliers)
  - To verify the implementation of the (software) product assurance programme

5.2.4

- **Alerts to be treated in accordance with ECSS-Q-ST-10, subclause 5.2.9**
  - The supplier to participate in the alert system organized by the customer or other sources
  - *ESA* maintains an alert system

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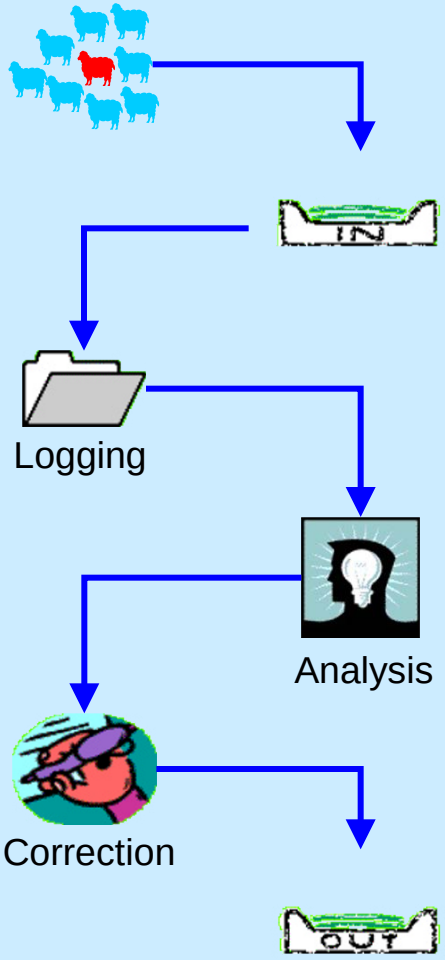
Software problems

5.2.5

- The supplier must define and implement procedures for software problems logging, analysis and correction
- Detailed content of software problem report (SPR) specified
- Interface with nonconformance system to be defined
- Verify correct implementation of SPR procedures



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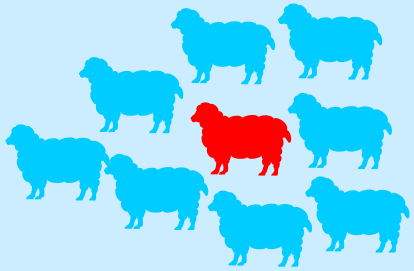
Nonconformances

- **The supplier must define and implement a nonconformance control system in accordance with ECSS-Q-ST-10-09**
  - Identification, classification, segregation, reporting, review, analysis, disposition of NCRs
  - Corrective and preventive actions

5.2.6

- **SW product assurance and SW engineering must be represented in nonconformance review boards**
- **The supplier to specify when NCR management for software starts**



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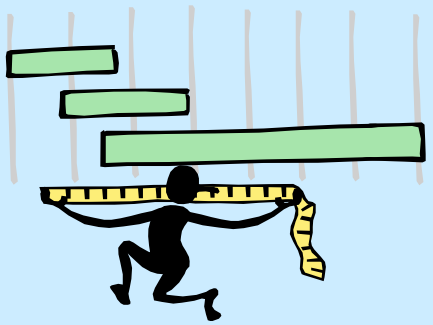
ECSS-Q-HB-80-04A SW metrication

- **Background**
- **Overview of the handbook**
  - **Quality models**
    - **Definition**
    - **Tailoring**
  - **Measurement Process**
    - **Planning**
    - **Data collection, validation, analysis and archiving**
    - **Report of results**
    - **Feedback**



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ECSS-ST-Q-80C - definitions

Quality model (software)

set of **characteristics** and relationships between them which provide the basis for specifying quality requirements and evaluating quality

[ISO/IEC 9126-1], [ECSS-Q-ST-80C]

Quality characteristics (software)

set of attributes of a software product by which its quality requirements is described and evaluated

[ECSS-Q-ST-80C]

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ECSS-ST-Q-80C requirements and quality models (1/4)

- **Quality models must be used to specify quality requirements**
- **Mandatory quality characteristics:**
  - functionality
  - reliability
  - maintainability
  - reusability
  - suitability for safety
  - security
  - usability
  - efficiency
  - portability
  - software development effectiveness

5.2.7

Quality models are defined e.g. in

ISO 9126

ECSS-Q-HB-80-04

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ECSS-ST-Q-80C requirements and quality models (2/4)

7.1.1

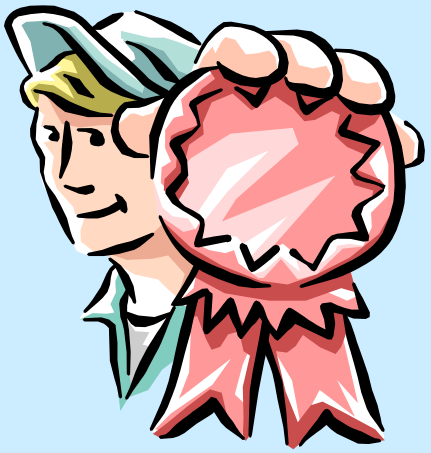
- **Software quality requirements (including safety) derive from system requirements**

7.1.2

- **Quality requirements must be expressed in quantitative terms**
  - As far as possible, at least…

7.1.3

- **The software product assurance function must ensure that quality requirements are documented in the technical specification**
  - Not only the SPAP



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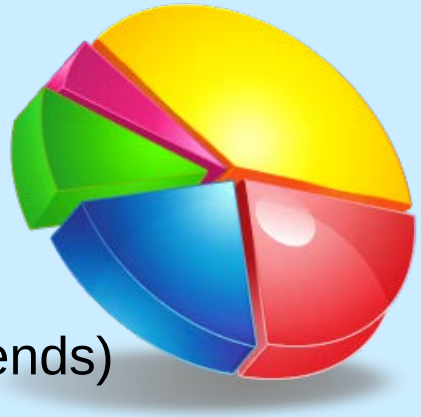
ECSS-ST-Q-80C requirements and quality models (3/4)

7.1.4

- **The supplier must define a metrication programme to verify the implementation of quality requirements**
  - metrics to be collected
  - means to collect the metrics
  - target values
  - analyses to be performed (statistic, trends)
  - usage of metrics (corrective actions)
  - schedule of collection



7.1.5

- **Mandatory basic metrics must be used**
  - Size, complexity, failures, test coverage

7.1.6

- **Metrics must be reported regularly**

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ECSS-ST-Q-80C requirements and process metrics(4/4)

6.2.5.1
6.2.5.2

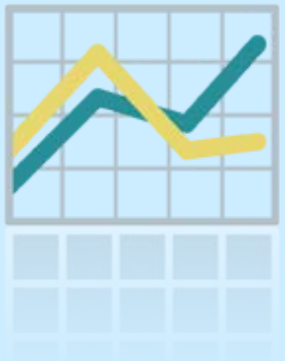
- **The supplier must collect, store and analyze process metrics, to assess the quality of the development processes**
  - Process metrics are based on quality models (5.2.7)

6.2.5.3
6.2.5.4

- **Mandatory basic metrics to be**
  - used internally (duration and effort)
  - reported to customer (No of problems during V&V)

6.2.5.5

- **The supplier must include process metrics reports in the software product assurance reports**



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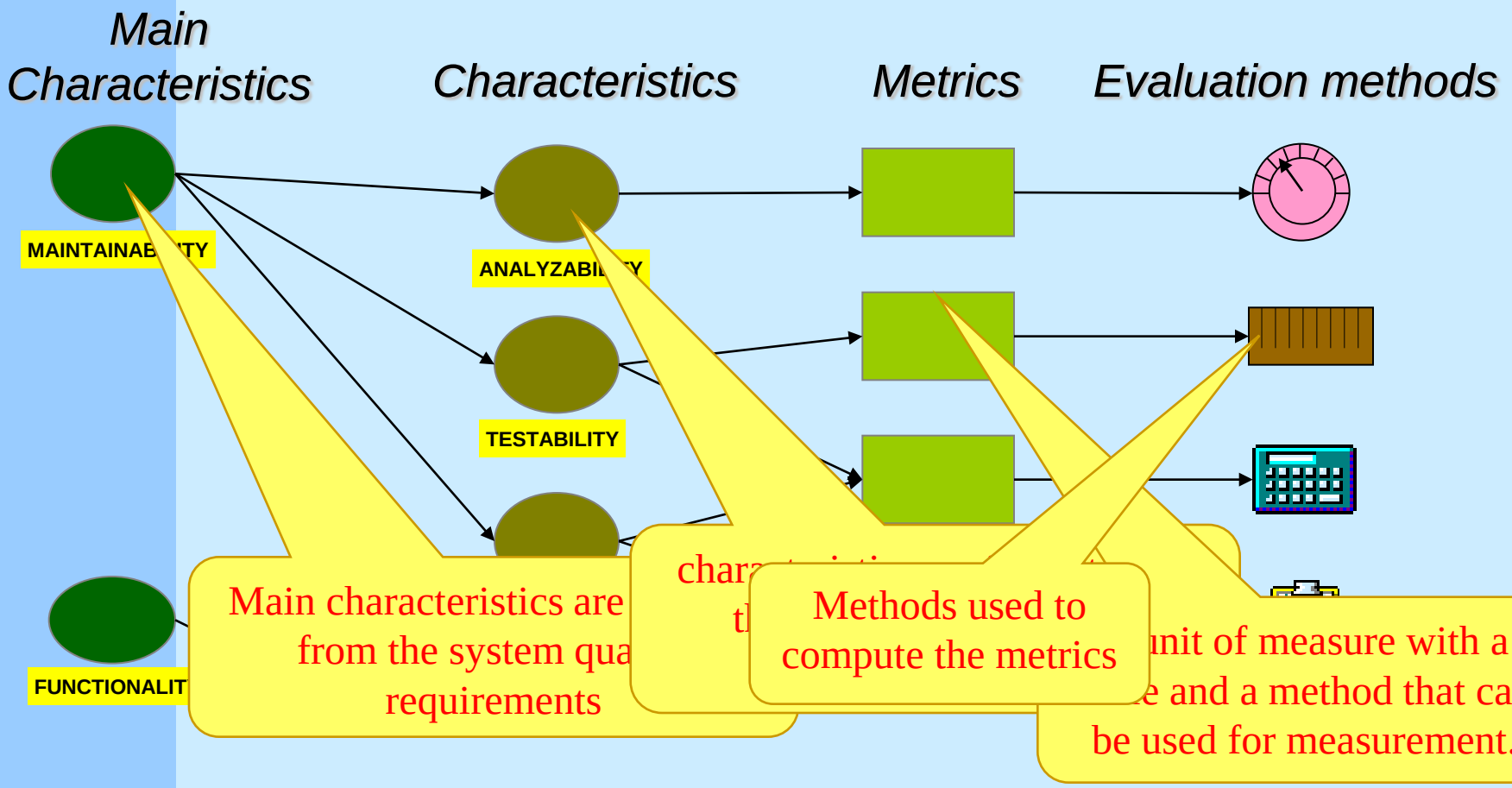
Quality requirements and quality models

- **Quality model is a defined set of characteristics that provides a framework for specifying quality requirements and evaluating quality**



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Risk management and critical item control

Software product assurance programme implementation

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Software product quality assurance

- 7.1 Product quality objectives and metrication
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- 7.5 Firmware

5.3.1 Risk management
5.3.2 Critical item control

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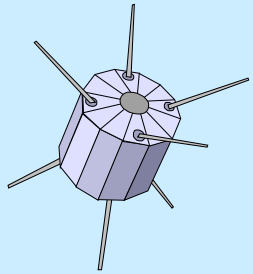
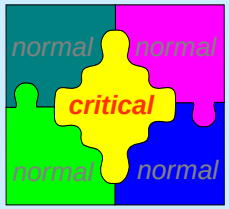
Risk management and critical item control

5.3.1

- The supplier must perform **risk management** in accordance with ECSS-M-ST-80
- Software risk management contributes to the **overall project risk policy**



5.3.2



- The supplier must perform **critical item control** in accordance with ECSS-Q-ST-10-04
- The **characteristics** which make SW candidate for C.I.L. must be identified

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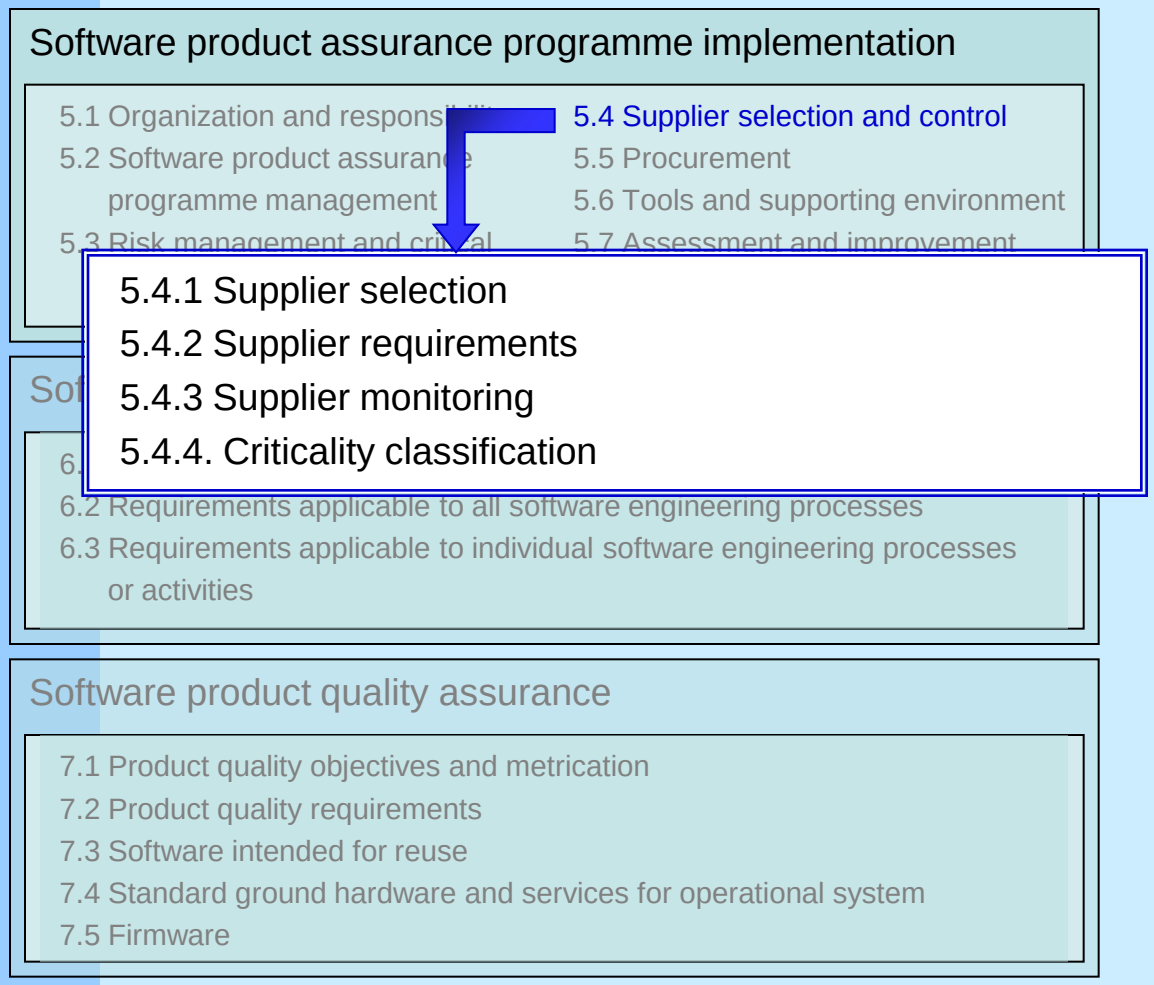
Risk management and critical item control



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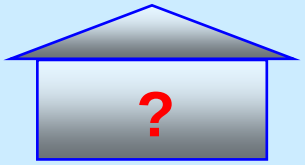
Supplier selection

5.4.1

- **The supplier must select lower level suppliers following the process specified in ECSS-Q-ST-20C, subclause 5.4.1**
  - QA function must be involved in selection
  - Criteria for selection (e.g. pre-award audit)
  - Records of suppliers to be maintained



- **For suppliers of COTS software, the reuse file must be made available and used in the selection process**
  - Selection of and negotiations with suppliers of COTS software based on knowledge of the actual status of the software being procured

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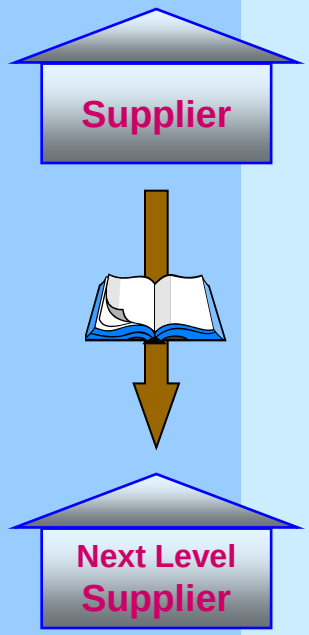
ECSS

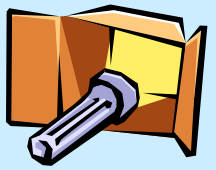
Supplier requirements and monitoring

5.4.3



- **The supplier must establish software product assurance requirements for lower level suppliers**
  - To be approved by the customer
- **The supplier must monitor the compliance of his suppliers with the SW PA requirements**
  - Verify definition and implementation of software development processes
  - Suppliers' product assurance plan to be provided to customer for approval
  - Continuous verification of processes and products

5.4.2



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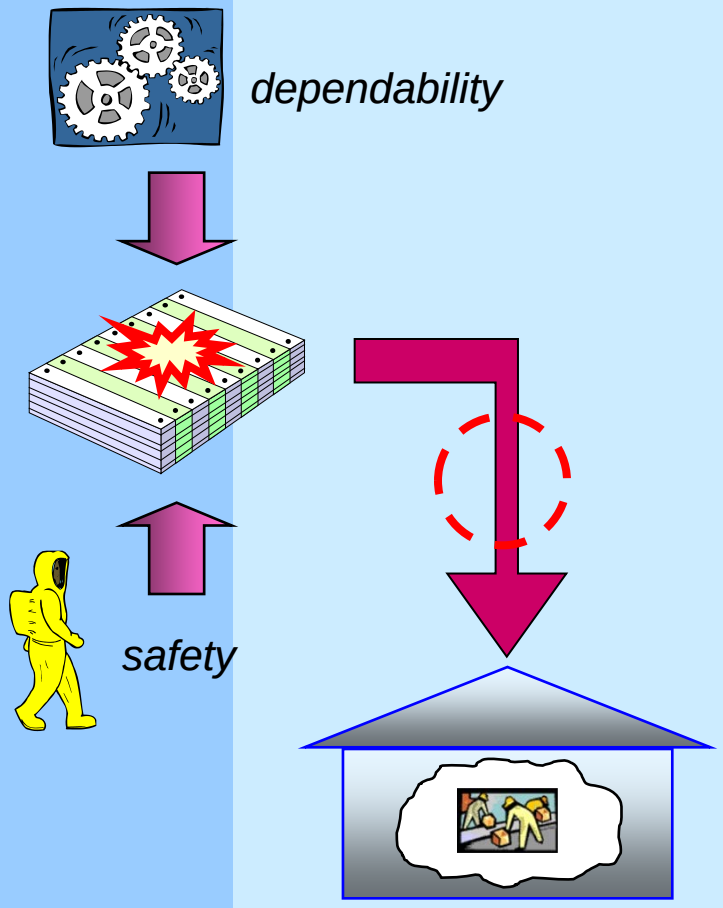
5.4.4

Criticality classification



- **The supplier must provide the lower level suppliers with the results of the RAMS analyses performed:**
  - at higher level
  - at his level
- **The lower level suppliers get:**
  - criticality classification of the software being procured
  - information on failures that led to that criticality classification

Linked to SW RAMS (6.2.2)

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Procurement

Software product assurance programme implementation

5.1 Organization and responsibility
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5.6 Tools and supporting environment
5.7 Assessment and improvement process

- 5.5.1 Procurement documents
- 5.5.2 Review of procured software component list
- 5.5.3 Procurement details
- 5.5.4 Identification
- 5.5.5 Inspection
- 5.5.6 Exportability

Software product quality assurance

7.1 Product quality objectives and metrication
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Procurement

5.5

- **For procured (non-developed) software**
- **ECSS-Q-ST-20C, subclause 5.4.2, applies**
  - Clear, complete and traceable requirements
  - QA requirements to be included
  - QA function to review the procurement documentation
- **Procured software details to be provided to the customer**
- **Procured software must be inspected and put under configuration control**
- **Mind exportability**

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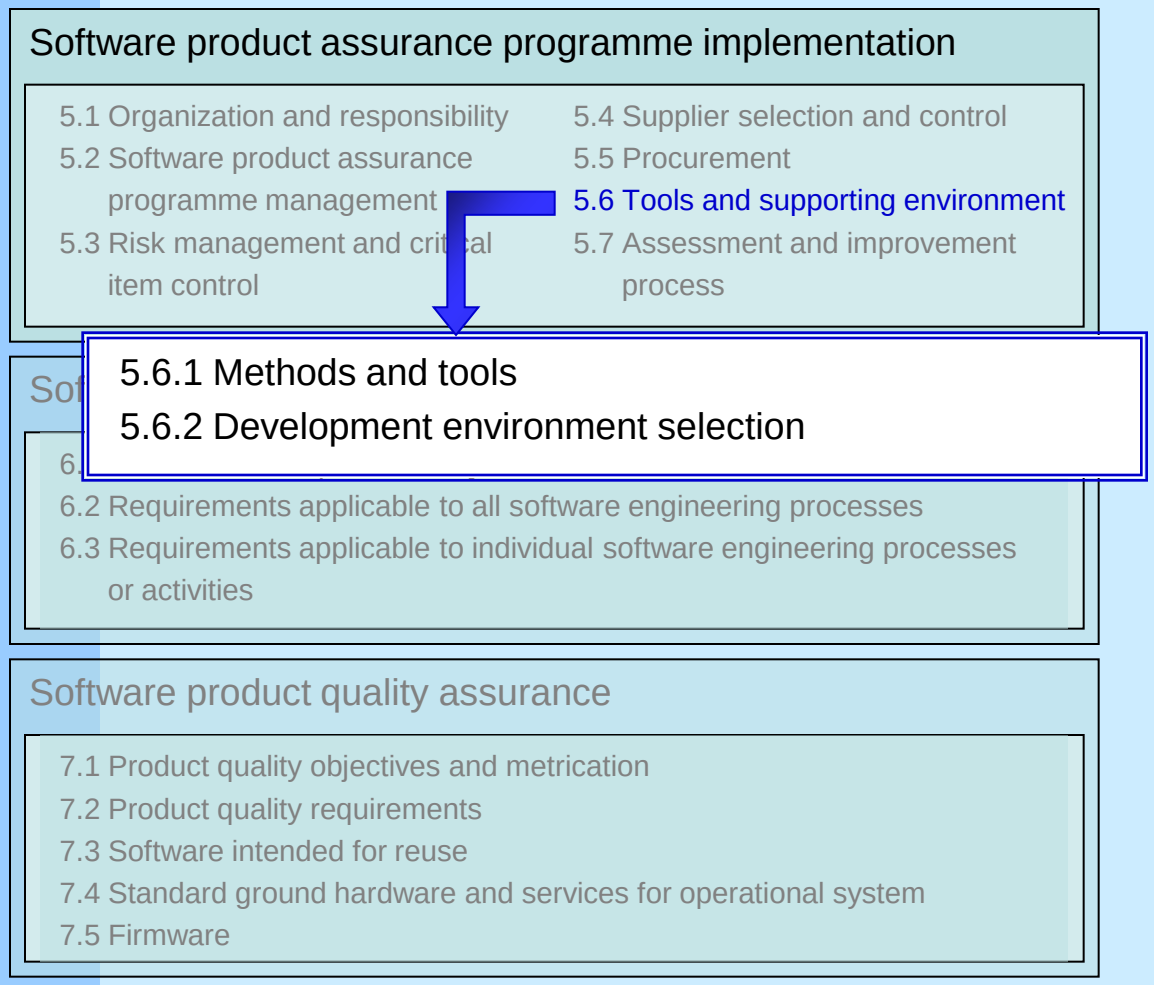
Tools and supporting environment



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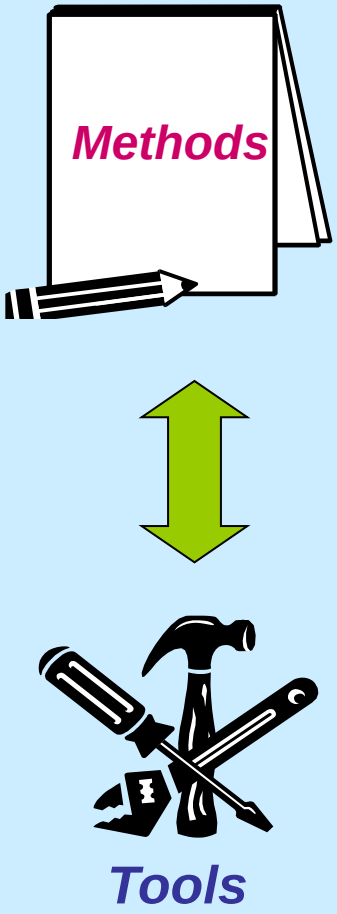
Methods and tools

5.6.1

- **The supplier must identify in the SPAP all used methods and tools**
- **Justify the choice of those methods and tools in the SPAMR**
  - The team knows how to use them
  - They are appropriate and available for this project
- **Verify the correct use of methods and tools**



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Software development environment

5.6.2

- **Development environment to be chosen based on specific criteria**
  - availability
  - performance
  - maintenance
  - …
- **Justification of suitability for the current project to be provided to the customer**
- **The development environment must be available to the team at the start of each phase**

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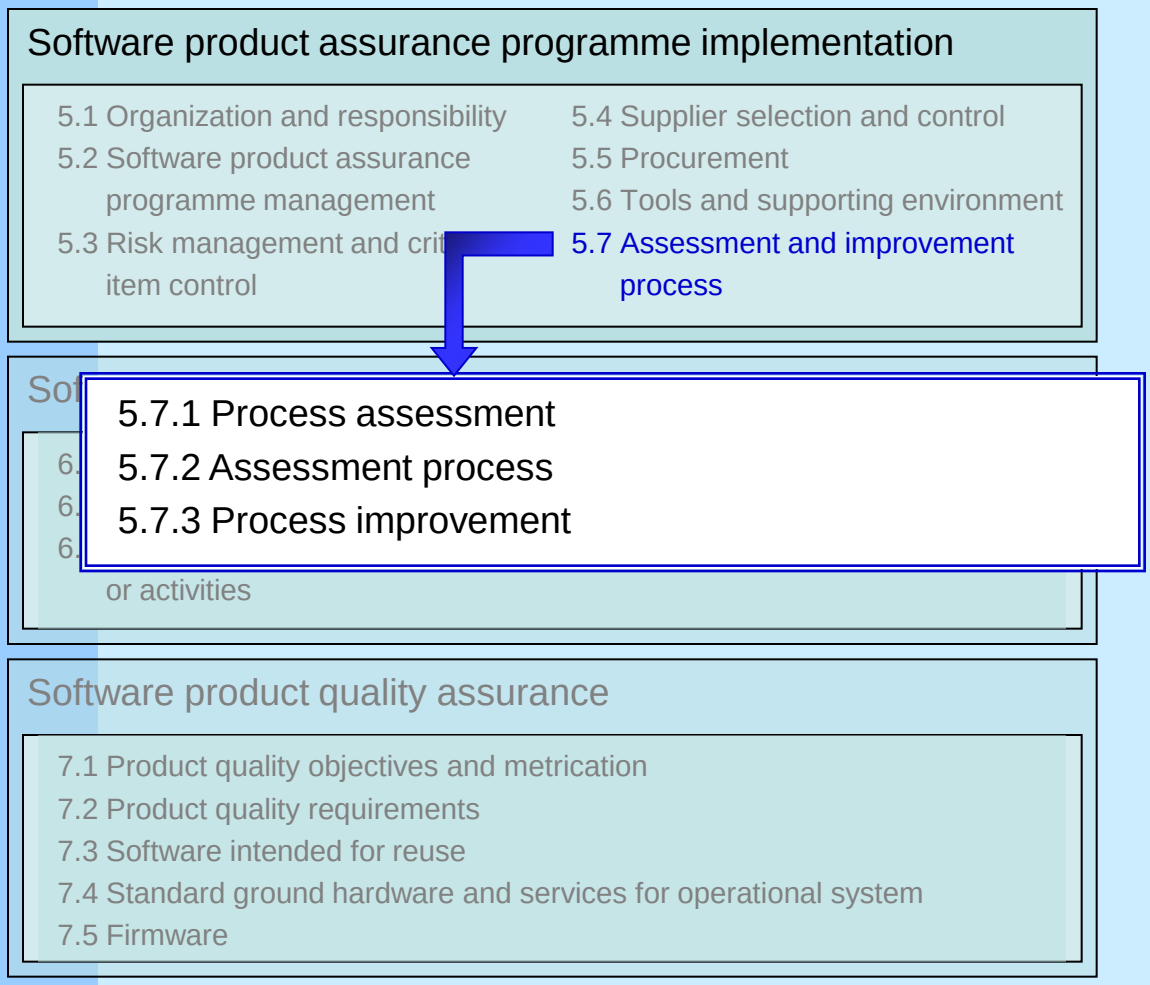
Assessment and improvement process



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Process assessment

5.7.1

- **The supplier must monitor and control the effectiveness of the processes used during the development of the software**

- **Not necessarily performed at project level**
  - The process assessment and improvement performed at organization level can be used to provide evidence of compliance for the project
- **The supplier must provide evidence that a process assessment and improvement process is in place in its organization**
  - Records to be made available

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Assessment process

5.7.2

- **The process assessment model and method used to perform software process assessment must be documented**
- **Models and actual assessments must comply with SPiCE (ISO/IEC 15504)**
  - But…CMMI model + SCAMPI A methods are OK
  - ECSS-Q-HB-80-02 contains a method and a model which are conformant to ISO 15504
- **Assessments must be performed by skilled personnel**
  - ISO 15504 ⇒ competent assessor
  - CMMI ⇒ SEI authorized lead appraiser

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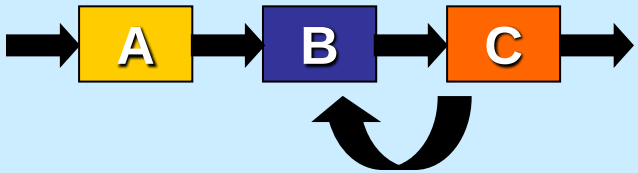
Process improvement

5.7.3

- **Use the results of process assessment to:**
  - improve the processes
  - recommend changes
  - determine technology needs
- **Process improvement process to be documented**
  - ECSS-Q-HB-80-02 and CMMI Organization Process Focus provide guidance
- **Evidence of improvement to be documented**



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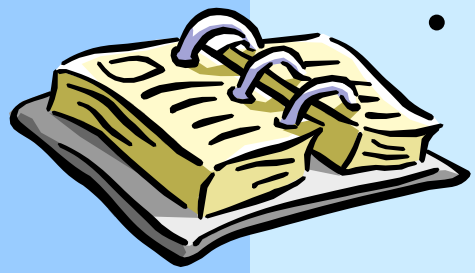
Content of the handbook

Part 1: Framework

- **Process Assessment model**
- **Process Assessment method**
- **Process Improvement**
- **Recognition of assessment schemes and results**

Part 2: Assessor instrument

- **Process Assessment model: Process dimension**
- **Process Assessment model: Capability dimension**



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Process Assessment Model: Capability Dimension

Each process is assessed looking at its attributes:

Level 1 - Performed process

Process performance

Level 2 - Managed process

Performance management
Work product Management

Level 3 - Established process

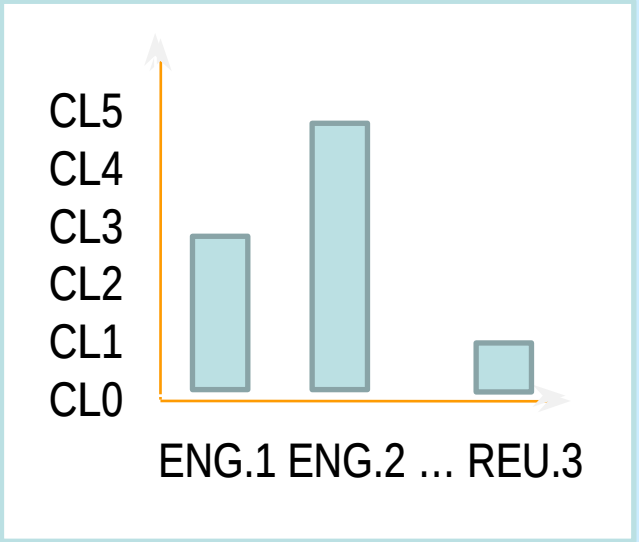
Process definition and Tailoring
Process resource

Level 4 - Predictable process

Process measurement
Process control

Level 5 - Optimising process

Process change
Continues improvement



Evaluation of more demanding attributes can be avoided if the assessment is targeted to a specific capability level

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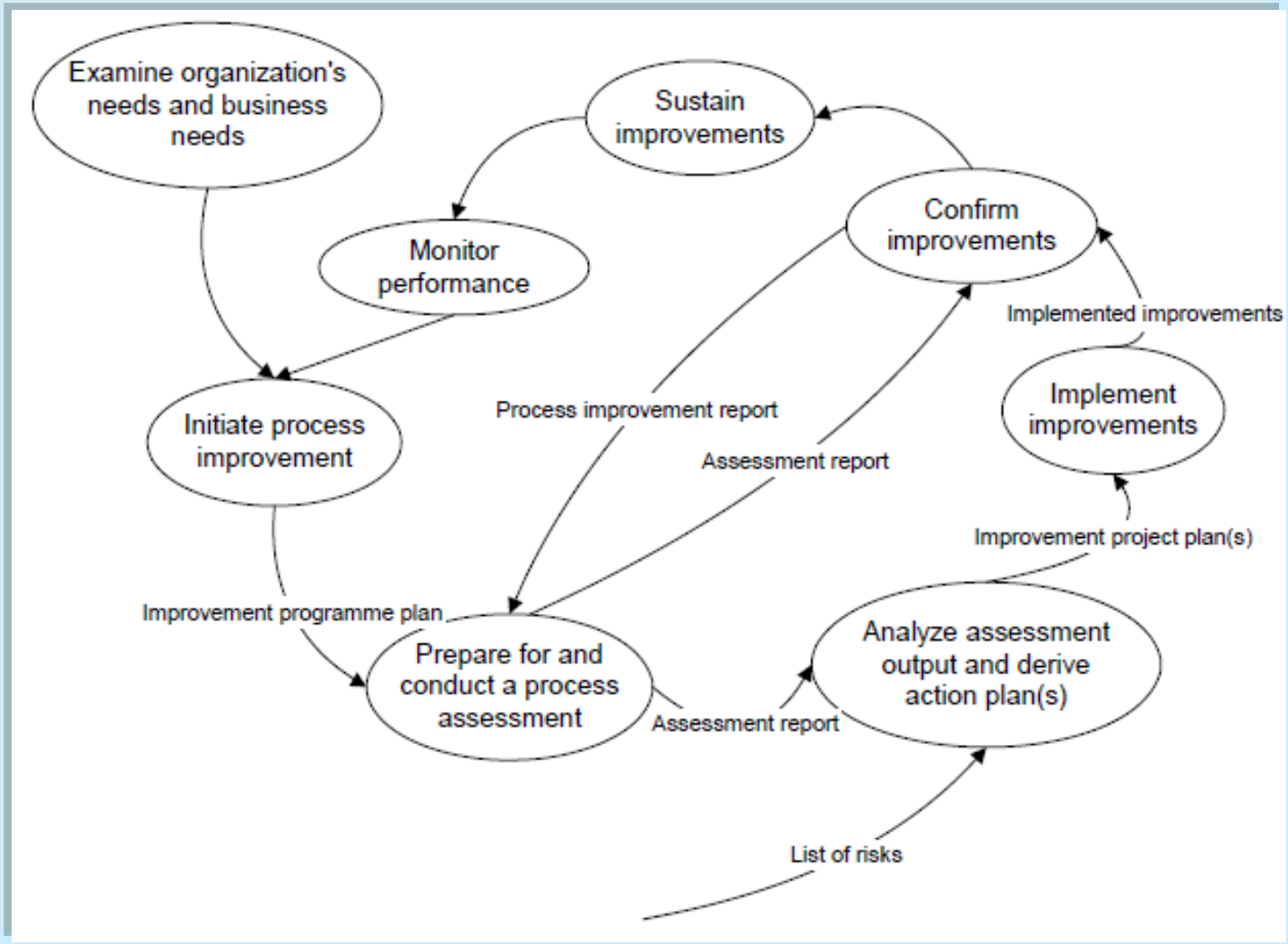
Process Improvement Cycle



Process Assessment Model: Process Dimension

PRIMARY LIFECYCLE PROCESSES

ACQUISITION:
ACQ.1 Acquisition Preparation
ACQ.2 Supplier Selection
ACQ.3 Contract Agreement
ACQ.4 Supplier Monitoring
ACQ.5 Customer Acceptance
ACQ.6 Contract Maintenance (*)

SUPPLY:
SPL.1 Supplier Tendering
SPL.2 Product Release
SPL.3 Product Acceptance Support

ENGINEERING:
ENG.1 Requirements Elicitation
ENG.2 System Requirements Analysis
ENG.3 System Architecture Design
ENG.4 Software Requirements Analysis
ENG.5 Software Design
ENG.6 Software Construction
ENG.7 Software Integration
ENG.8 Software Testing
ENG.9 System Integration
ENG.10 System Testing
ENG.11 Software Installation
ENG.12 Software and System Maintenance

OPERATION:
OPE.1 Operational Use
OPE.2 Customer Support

SUPPORTING LIFECYCLE PROCESSES

SUPPORTING:
SUP.1 Quality Assurance
SUP.2 Verification
SUP.3 Validation
SUP.4 Joint Review
SUP.5 Audit
SUP.6 Product Evaluation
SUP.7 Documentation
SUP.8 Configuration Management
SUP.9 Problem Resolution Management
SUP.10 Change Request Management
SUP.11 Safety and Dependability Assurance (*)
SUP.12 Independent Software Verification and Validation (*)

ORGANIZATIONAL LIFECYCLE PROCESSES

MANAGEMENT:
MAN.1 Organizational Alignment
MAN.2 Organizatioin Management
MAN.3 Project Management
MAN.4 Quality Management
MAN.5 Risk Management
MAN.6 Measurement
MAN.7 Information Management (*)

PROCESS IMPROVEMENT:
PIM.1 Process Establishment
PIM.2 Process Assessment
PIM.3 Process Improvement

RESOURCE AND INFRASTRUCTURE:
RIN.1 Human Resource Management
RIN.2 Training
RIN.3 Knowledge Management
RIN.4 Infrastructure

REUSE:
REU.1 Asset Management
REU.2 Reuse Program Management
REU.3 Domain Engineering

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Software Process Assurance

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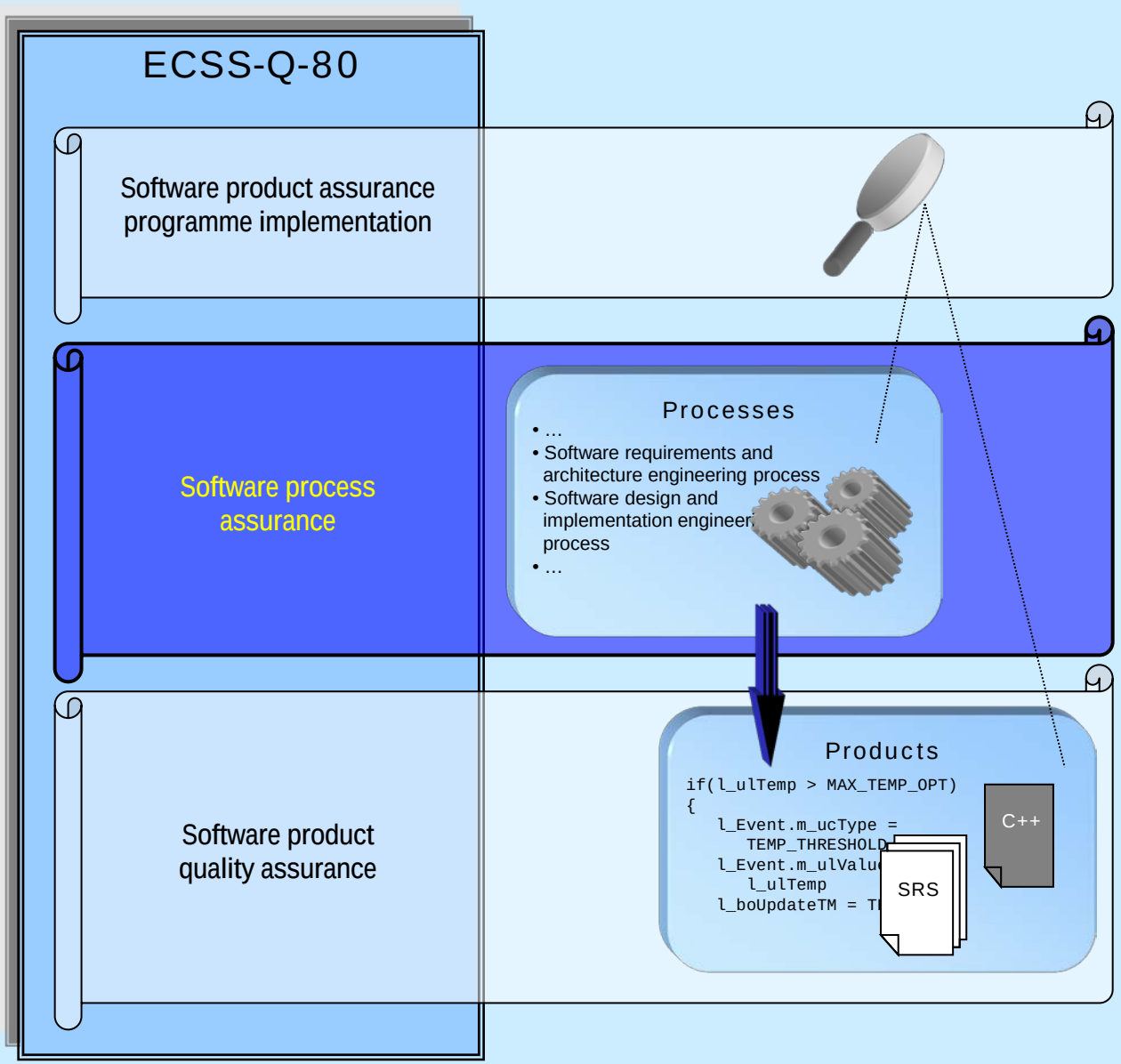
Clause 6

Ensuring the quality of the process



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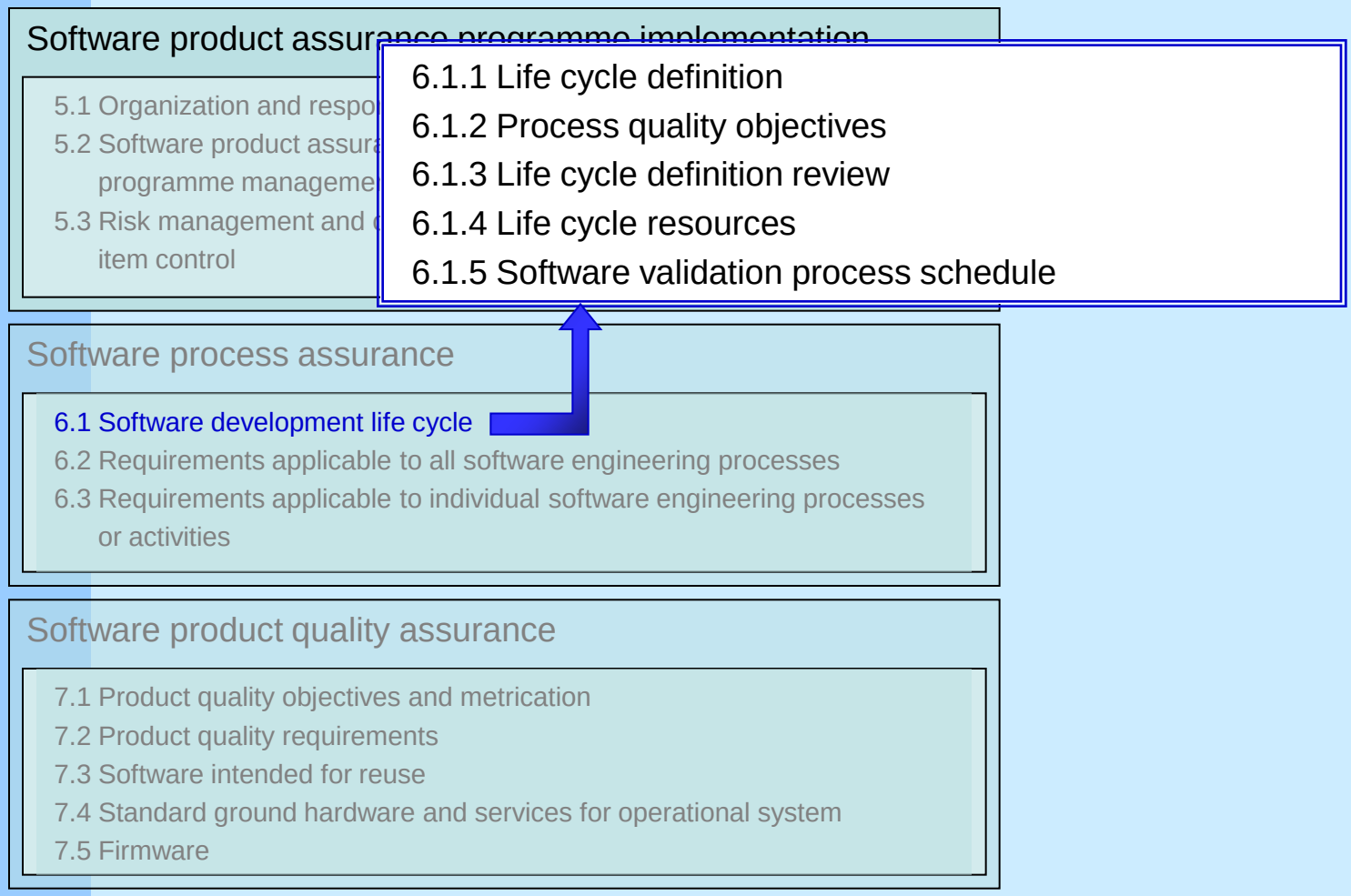
Software development life cycle



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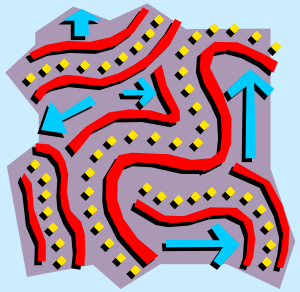
Life cycle definition

6.1.1

- **The software development life cycle must be defined in the software development plan and referenced in the SPAP**
  - If not defined in the development plan, the life cycle must be defined in the SPAP
- **Life cycle characteristics to be provided**
  - phases and milestones
  - input, output and state of completion at end of phase
  - dependencies
  - responsibilities
  - role of customer at reviews



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Life cycle: quality objectives, review, resources and validation

6.1.2

- **Use quality objectives when defining life cycle**
- **Software life cycle must be reviewed**

6.1.3

  - against contractual requirements

6.1.4

  - for suitability and availability of resources

- **A milestone must be scheduled immediately before the starting of software validation**

6.1.5

  - check is software status is compatible
  - check if resources, documents and equipments are OK to start validation
  - software Test Readiness Review

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Requirements applicable to all software engineering processes

Software product assur

5.1 Organization and respo
5.2 Software product assura
programme manageme
5.3 Risk management and
item control

Software process assu

6.1 Software development life cycle
6.2 Requirements applicable to all software engineering processes
6.3 Requirements applicable to individual software engineering processes or activities

Software product quality assurance

7.1 Product quality objectives and metrication
7.2 Product quality requirements
7.3 Software intended for reuse
7.4 Standard ground hardware and services for operational system
7.5 Firmware

6.2.1 Documentation of processes
6.2.2 Software dependability and safety
6.2.3 Handling of critical software
6.2.4 Software configuration management
6.2.5 Process metrics *(already covered)*
6.2.6 Verification
6.2.7 Reuse of existing software
6.2.8 Automatic code generation

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Documentation of processes (1/2)

6.2.1

- **The supplier must generate plans (either software specific or at project level) to cover:**
  - development;
  - specification, design and customer documents to be produced;
  - configuration and documentation management;
  - verification, testing and validation activities;
  - maintenance.
- **The SPAP identifies all plans to be produced and used, the relationship between them and the time-scales for their preparation and update.**

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Documentation of processes (2/2)

6.2.1

- The supplier must generate or identify procedures and standards to be used for all type of software in the project
- Plans must be reviewed against contractual requirements
- Procedures and standards must be reviewed against plans and contractual requirements
- Plans, procedures and standards must be finalized before the start of the activities
- Plans must be updated at each milestone to reflect development changes

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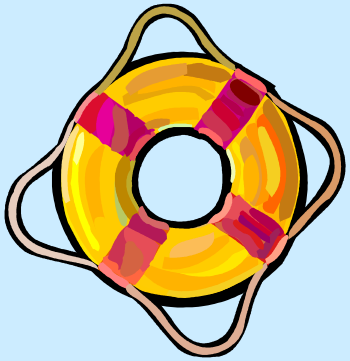
Software dependability and safety (1/15)

6.2.2

- **Software RAMS**
  - Reliability
  - Availability
  - Maintainability
  - Safety

} Dependability

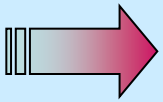


- **Software RAMS activities start at system level and continue at software level, with feedback**
- **Main objectives:**
  - Identify the critical software
  - Depending on the criticality of the software, different ECSS-E-ST-40C and ECSS-Q-ST-80C requirements are applied (pre-tailoring)

Software dependability and safety (2/15)

6.2.2.1

- **At system level:**
  - Dependability analyses
  - (ECSS-Q-ST-30 Rev.1)
  - Safety analyses (ECSS-Q-ST-40 Rev.1)



Criticality classification of system functions and *(software)products*

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Software dependability and safety (3/15)

- **System-level criticality classification**
  - **The criticality categorization of functions is clarified and harmonized across Q-30/Q-40 Rev.1**
  - **Function criticality is directly linked to the severity of failure/hazard consequences without considering compensating provisions.**
  - **The criticality of SW is assigned considering the overall system design. In particular whether compensating provisions exist that can prevent or mitigate failure consequences (e.g. inhibits, monitors, back-ups, operational procedures).**

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Software dependability and safety (4/15)

Function criticality	Criteria to assign criticality categories to functions	Severity	Dependability consequences	Safety consequences
I	*A function that if not or incorrectly performed , or whose anomalous behavior can cause one or more feared/hazardous events resulting in ...* ...**catastrophic consequences**	**Catastrophic** (Level 1)	Failure Propagation	• Loss of life, life-threatening or permanently disabling injury or occupational illness • Loss of system • Loss of an interfacing manned flight system • Loss of launch site facilities • Severe detrimental environmental effects
II	... **critical consequences**	**Critical** (Level 2)	Loss of mission	• Temporarily disabling but not life-threatening injury, or temporary occupational illness • Major damage to an interfacing flight system • Major damage to ground facilities • Major damage to public or private property • Major detrimental environmental effects
III	... **major consequences**	**Major** (Level 3)	Major mission degradation	
IV	... **minor or negligible consequences**	**Minor or Negligible** (Level 4)	Minor mission degradation or any other effect	

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Software dependability and safety (5/15)

- **Conditions are established for acceptable compensating provisions in the SW criticality assignment, i.e.**
  - Effectiveness of compensating provisions (for the purpose of “downgrading”) must be demonstrated in all conditions
  - There must be sufficient time to intervene in all situations
  - Probabilistic assessment cannot be used as a criterion for SW criticality classification.
  - In case the compensating provisions contain software, this software shall be classified at the criticality category corresponding to the highest severity of the failure consequences that they prevent or mitigate.

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Software dependability and safety (6/15)

Function criticality	Criticality category to be assigned to a software product
I	**Criticality category A** if the software product is the sole means to implement the function
	Criticality category B if, in addition, at least one of the following compensating provisions is available, meeting the requirements defined in clause 5.4.2: • A hardware implementation • A software implementation; this software implementation shall be classified as criticality A • An operational procedure
II	**Criticality category B** if the software product is the sole means to implement the function
	Criticality category C if, in addition, at least one of the following compensating provisions is available, meeting the requirements defined in clause 5.4.2: • A hardware implementation • A software implementation; this software implementation shall be classified as criticality B • An operational procedure
III	**Criticality category C** if the software product is the sole means to implement the function
	Criticality category D if, in addition, at least one of the following compensating provisions is available, meeting the requirements defined in clause 5.4.2: • A hardware implementation • A software implementation; this software implementation shall be classified as criticality C • An operational procedure
IV	**Criticality category D**

NOTE It should be noted that a too high level/incomplete functional decomposition, poorly accounting for safety and dependability aspects, could lead to a unnecessarily conservative software category classification.

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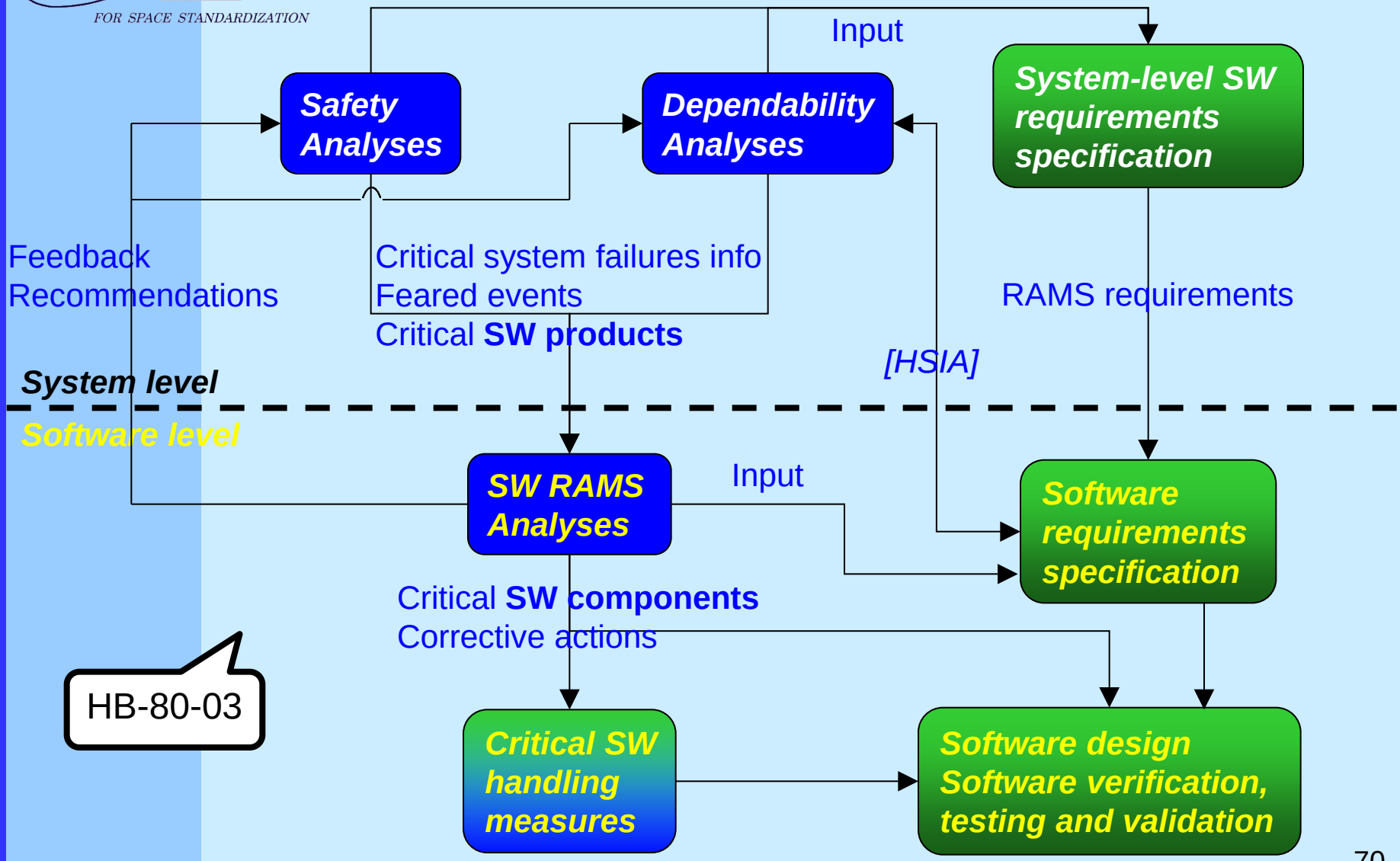
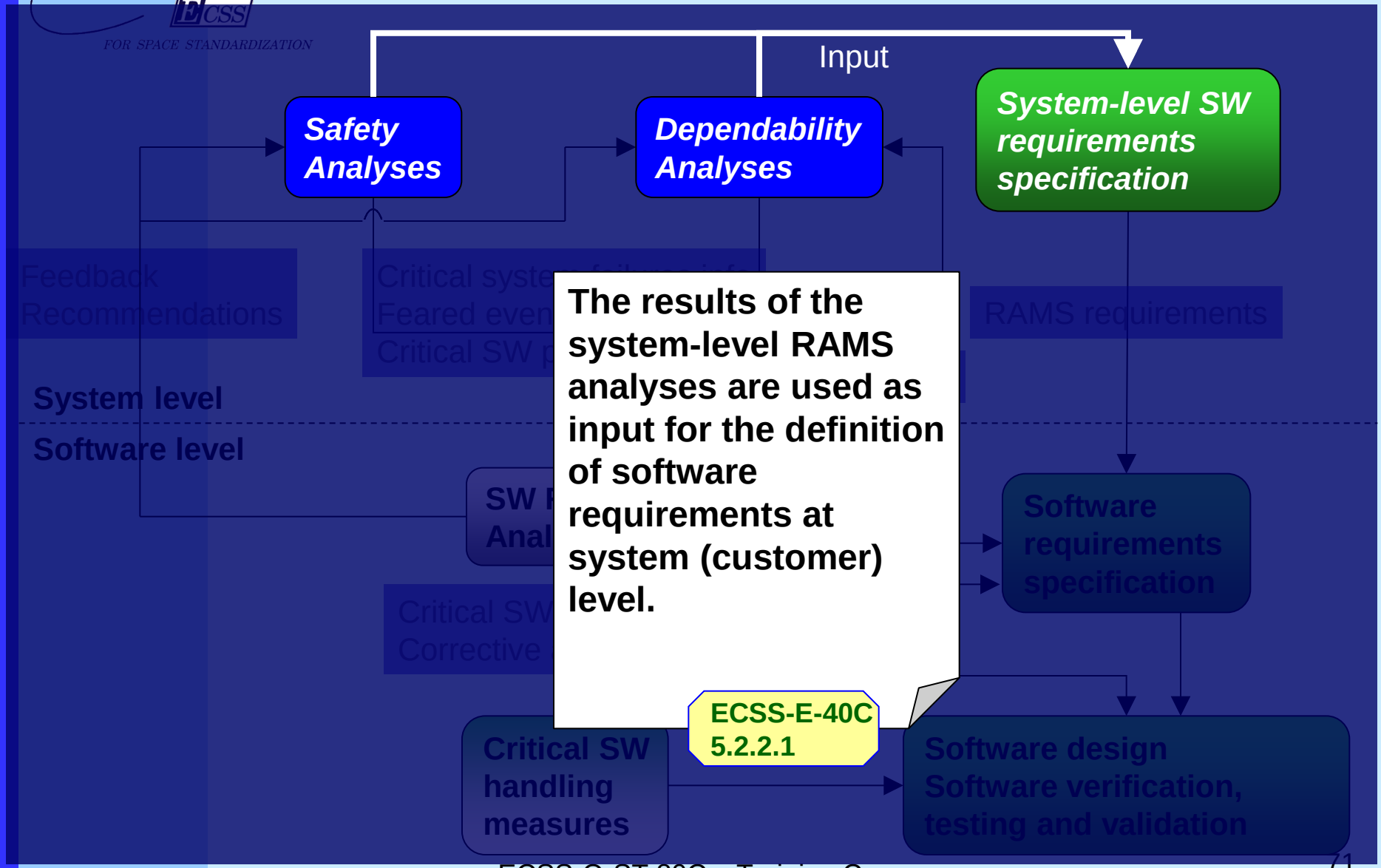
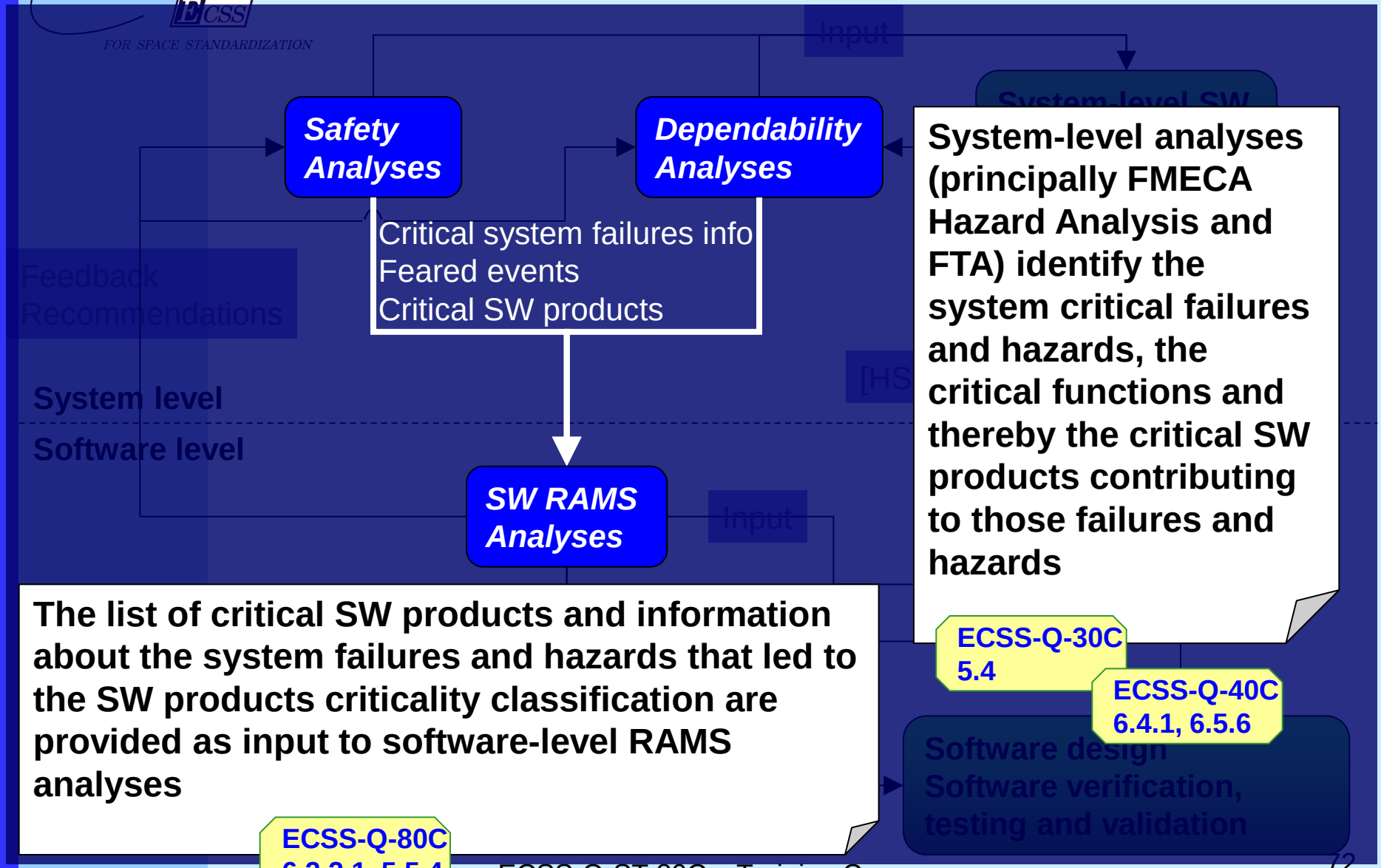
Software dependability and safety (7/15)



Software dependability and safety (8/15)



Software dependability and safety (9/15)



System-level analyses (principally FMECA Hazard Analysis and FTA) identify the system critical failures and hazards, the critical functions and thereby the critical SW products contributing to those failures and hazards

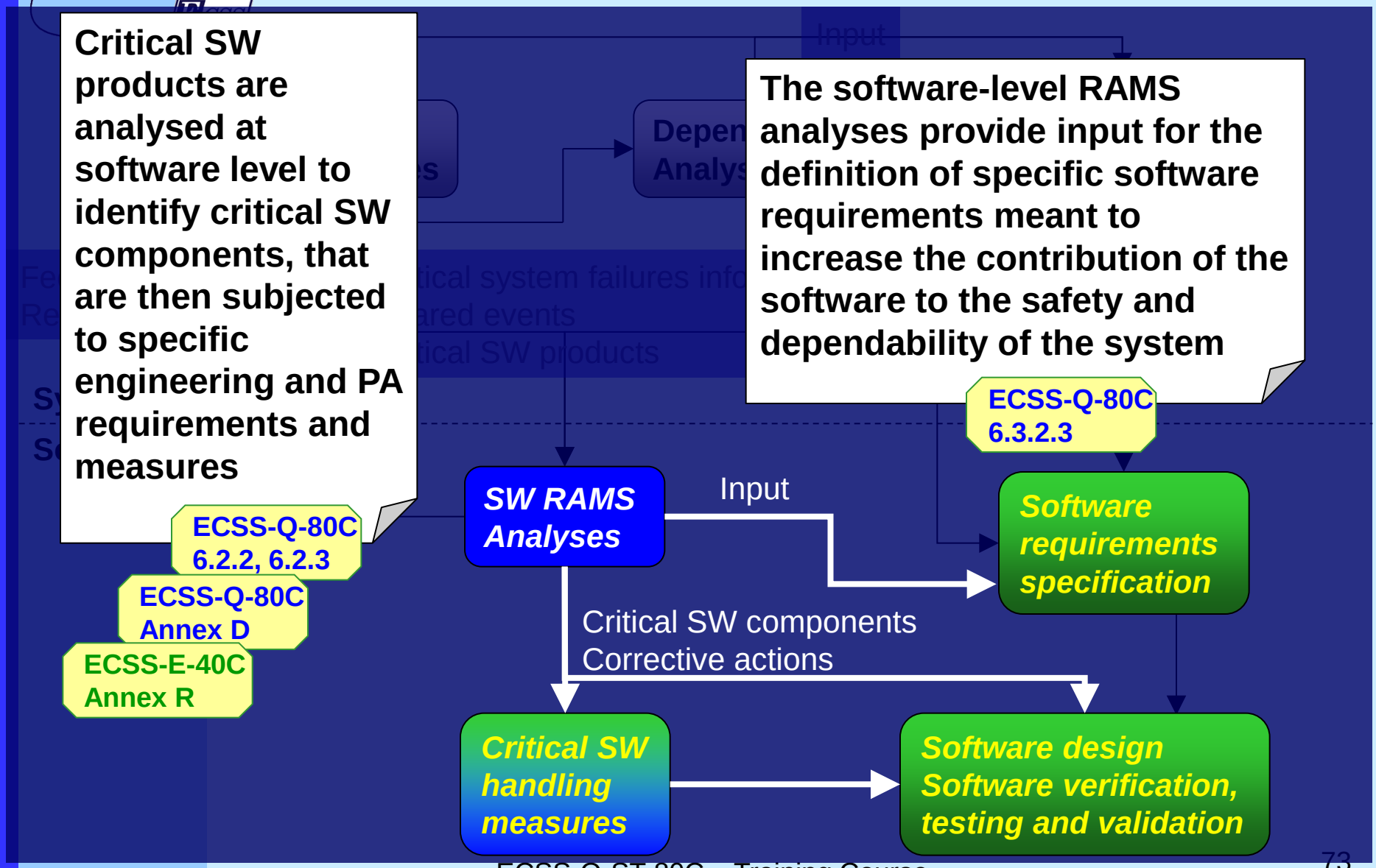
ECSS-Q-30C 5.4

ECSS-Q-40C 6.4.1, 6.5.6

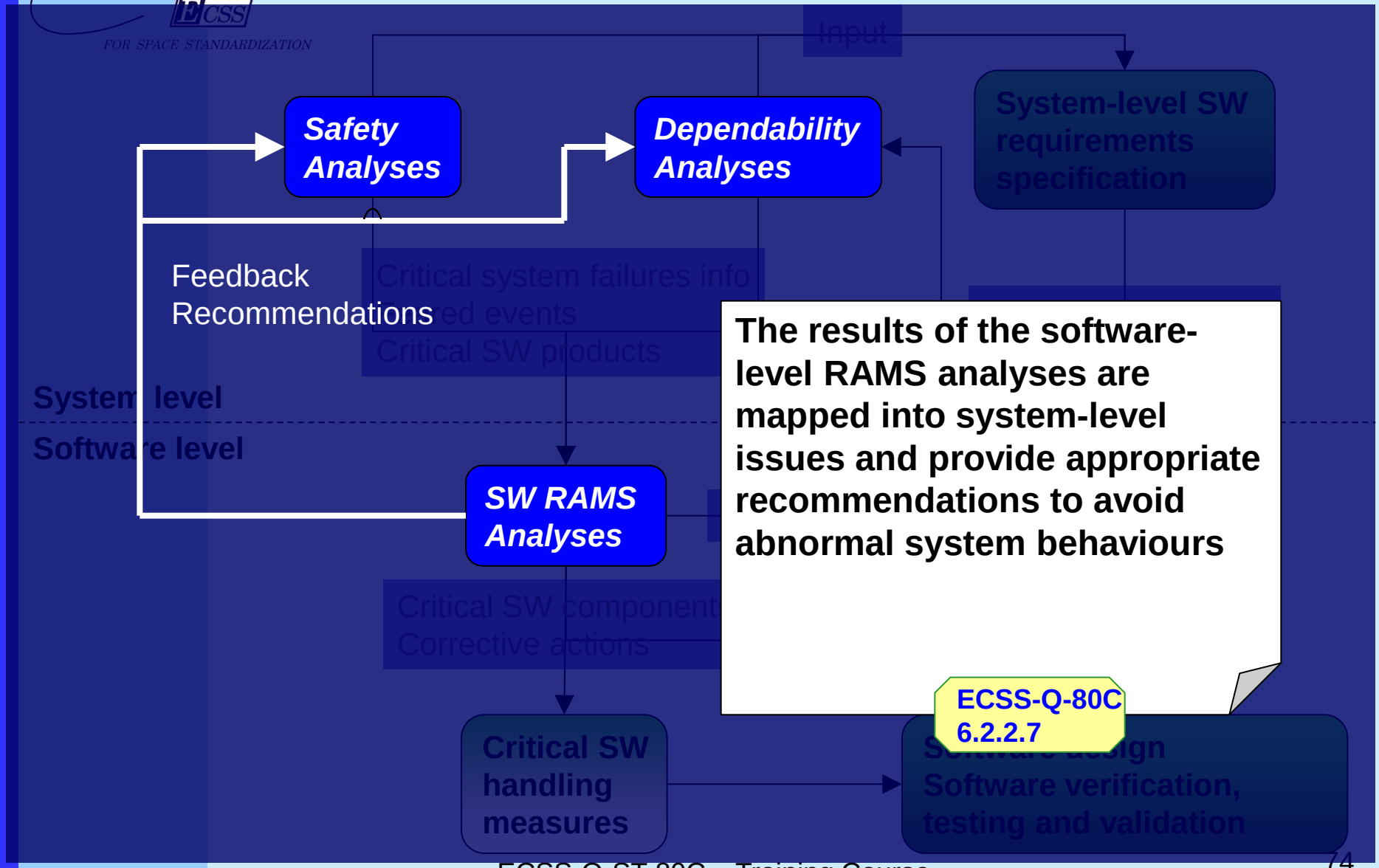
The list of critical SW products and information about the system failures and hazards that led to the SW products criticality classification are provided as input to software-level RAMS analyses

ECSS-Q-80C 6.2.2.1, 5.5.4

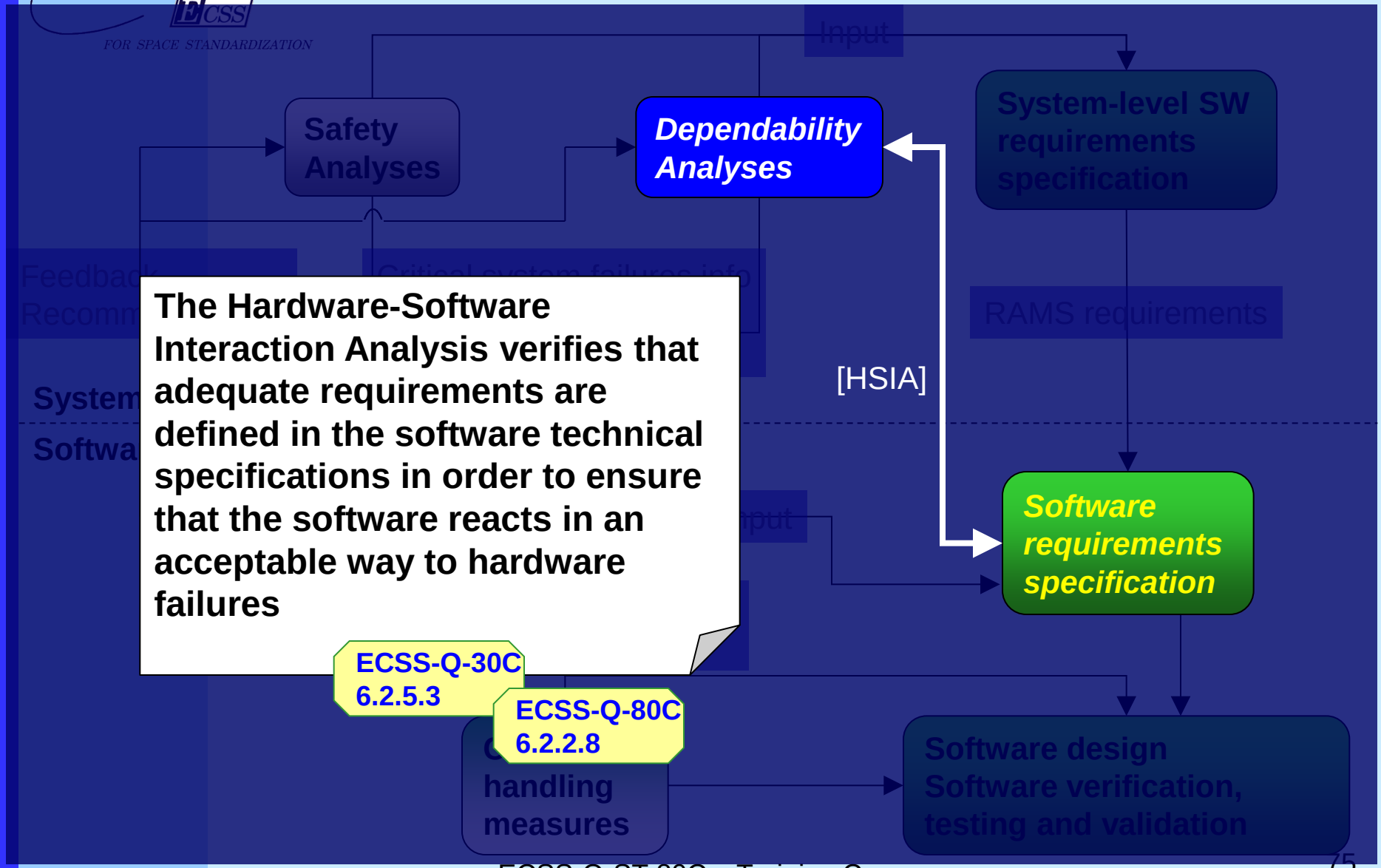
Software dependability and safety (10/15)



Software dependability and safety (11/15)



Software dependability and safety (12/15)



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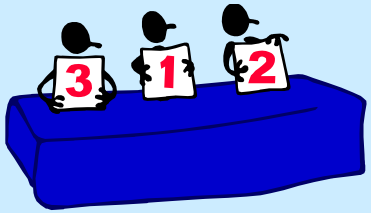
Software dependability and safety (13/15)

6.2.2.2

- **The supplier must perform a software dependability and safety analysis to determine the criticality category of software *components***



6.2.2.3

- **Analysis to be performed at technical specification and design level, e.g.:**
  - SFMECA
  - SFTA
  - SCCA

6.2.2.6

- **The software criticality classification must be confirmed at each milestone**

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Software dependability and safety (14/15)

6.2.2.4

- **The supplier must apply engineering measures to**
  - reduce the number of critical software components
  - mitigate the risks associated with the critical software (⇒ subclause 6.2.3)

6.2.2.7

- **Results of software level analyses are fed back to be integrated into system level analyses**
  - additional software failure modes identified
  - recommendations for the system
    - ➢ e.g. introduction of hardware inhibits, modification of system architecture

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Software dependability and safety (15/15)

- **Contribution of software to Hardware-Software Integration Analysis**

  6.2.2.8

  - Identify, for each hardware failure included in the HSIA, the requirements that specify the software behaviour in the event of that hardware failure

- **Verification of Hardware-Software Integration Analysis requirements**

  6.2.2.9

  - The software must react correctly to hardware failures
  - No undesired software behaviour, that may lead to system failures

- **Failure propagation to higher criticality**

  6.2.2.10

  - All involved components classified at higher criticality

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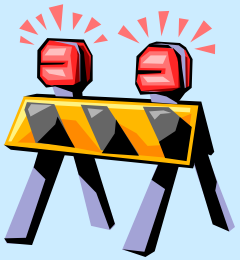
Handling of critical software (1/2)

6.2.3.1

- **Propagation of failures between SW components of different criticality must be prevented**
  - If impossible, all interested components classified to the same (highest) criticality



6.2.3.2

- **The supplier must define, justify and apply measures to assure the dependability and safety of critical software**
  - a set of measures is proposed

6.2.3.3

- **The correct implementation of the chosen measures must be verified and reported on**

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Handling of critical software (2/2)

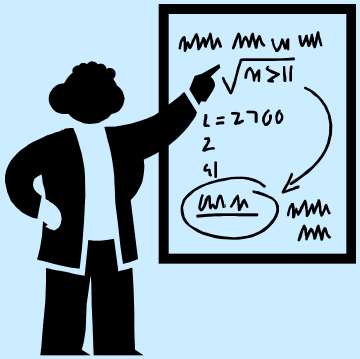
- **Specific requirements for critical software**

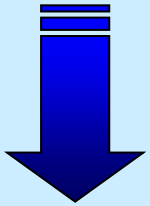
6.2.3.4
- Mandatory regression testing in case of change of hardware or development tools

6.2.3.5
- Potential need for additional verification and validation to be analyzed in case of change of hardware and environment

6.2.3.6
- Remove unreachable code

6.2.3.7
6.2.3.8
- Testing to be (re-)executed on non-instrumented code





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Software configuration management (1/2)

6.2.4.1

- **ECSS-M-ST-40 applies to software configuration management**
- **Additional requirements in ECSS-Q-ST-80 for assurance aspects**

6.2.4.2

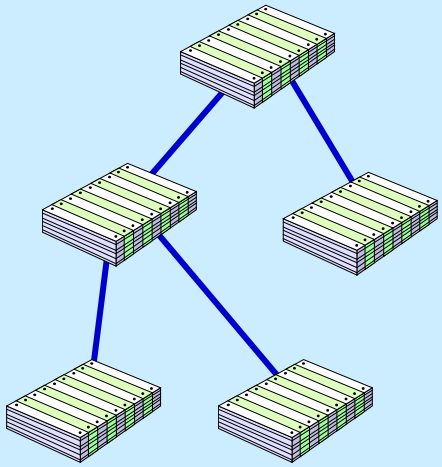
- It must be possible to regenerate any software reference version from back-ups

6.2.4.3
6.2.4.4

- Requirements for the release of software configuration file and software release document

6.2.4.6

- Verify that authorized changes are implemented as specified in the CM plan (PA task)



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Software configuration management (2/2)

6.2.4.7

- **Configuration control must be applied to**
  - Customizable code generation tools (e.g. compilers)
  - Planning documents (e.g. development plan)
  - Development documents (e.g. test specifications)

6.2.4.5

- **The change control procedures must address the customization of code generation tools**

6.2.4.8

- **Methods and tools must be identified and applied to prevent supplied software corruption**

6.2.4.9

  - Checksum on operational software

6.2.4.11

- **Marking of delivered media**

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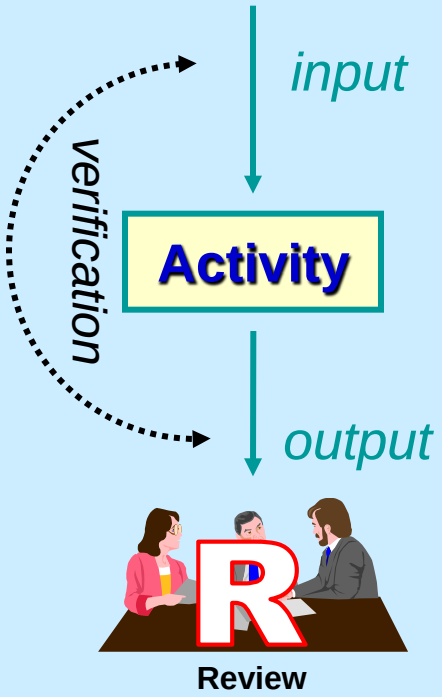
Verification (1/5)

6.2.6.1

- **Verification of quality requirements must be planned for**
- **Verification includes various techniques**
  - Basically paperwork, not testing
- **The outputs of each activity must be verified against pre-defined criteria**

6.2.6.2

- **Only outputs successfully verified can be used in subsequent activities**



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Verification (2/5)

6.2.6.7

- **The supplier must ensure that**
  - adequate verification activities are planned for
  - verification is carried out in accordance with the planning

6.2.6.4

- **The completion of actions linked to software problem reports generated during verification must be checked**

6.2.6.3

- **Assurance activities on verification and relevant findings must be reported on**

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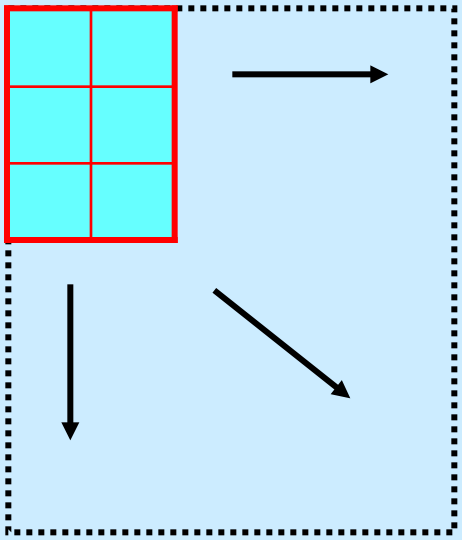
Verification (3/5)

- **Specific verification required for**

6.2.6.5

- deactivated code ⇒ no accidental or harmful activation

```
...
#ifdef BUS_1553
  /* deactivated */
#endif
...
```



6.2.6.6

- configurable code ⇒ no unintended configuration included in executable or activated at run-time

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Verification (4/5)

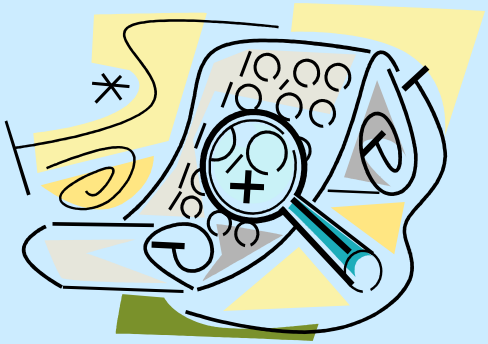
6.2.6.8

- **Reviews and inspections must be**
  - carried out according to defined criteria
  - performed by suitably independent personnel
  - based on written procedures
  - reported on

6.2.6.11

6.2.6.12

- **Verification of traceability matrices must be performed at each milestone review**



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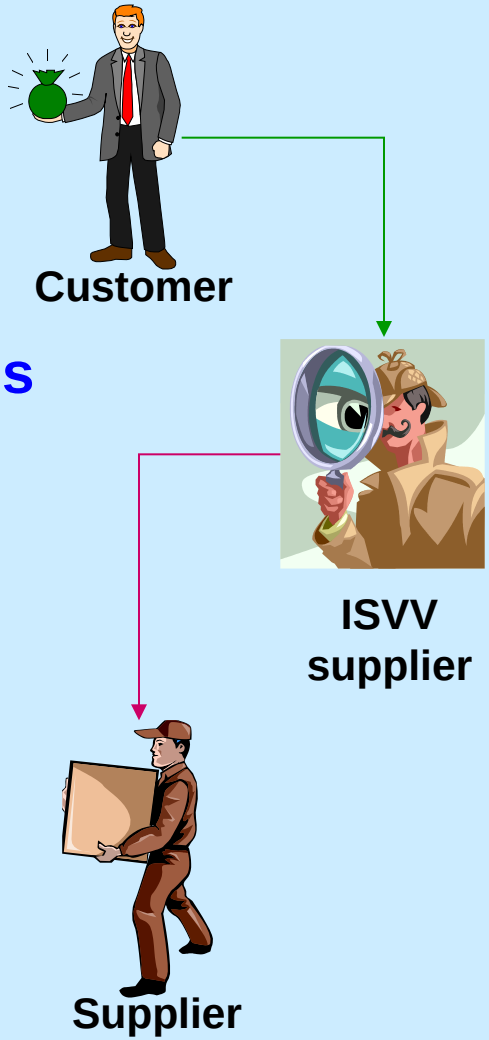
Verification (5/5)

6.2.6.13

- **Independent software verification must be performed by a third party**
- **ISVV includes several techniques**
  - review
  - inspection
  - analysis
  - …
- **Applicability and level of independence to be considered based on project risks…**



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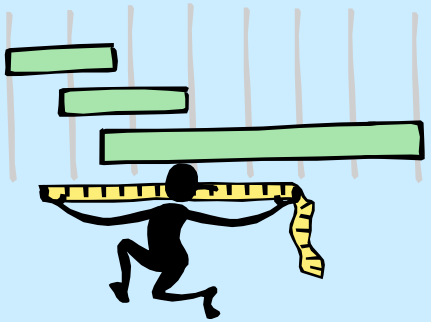
ECSS-Q-HB-80-01A (reuse of existing software)

- **Background**
- **Overview of the handbook**
  - **SW reuse approach**
  - **Tool qualification**
  - **Techniques to support qualification**
  - **Software reuse file (SRF)**
  - **Product Service History (PSH)**
  - **Risk management**



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Reuse of existing software (1/2)

6.2.7.2

- **Choice: reuse or develop from scratch?**
- **Analysis based on:**
  - assessment of existing software w.r.t. applicable requirements
  - evaluation of quality status of the existing software, including detailed information about the *documentation status, test coverage, nonconformances, performance*, etc.
  - other aspects, such as *warranty conditions, support documentation, conditions of installation and use, intellectual property rights, licencing*, etc.

6.2.7.6

- **The supplier must document the reuse analysis results in a software reuse file**

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Reuse of existing software (2/2)

6.2.7.5

- **The software reuse file must include an estimation of the level of reuse**

6.2.7.7

- **In case the software proposed for reuse does not meet the project requirements, the software reuse file must document the identified corrective actions, which can include**
  - reverse engineering
  - delta verification and validation
  - documentation of product service history

6.2.7.9

- **The software reuse file must be submitted to the customer for approval and updated at milestones to reflect corrective actions implementation**

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Content of the handbook

- **SW reuse approach**
  - **Requirement phase**
  - **Assessment phase**
  - **Integration phase**
  - **Qualification phase**
- **Tool qualification**
- **Techniques to support qualification**
- **Software reuse file (SRF)**
- **Product Service History (PSH)**
- **Risk management**

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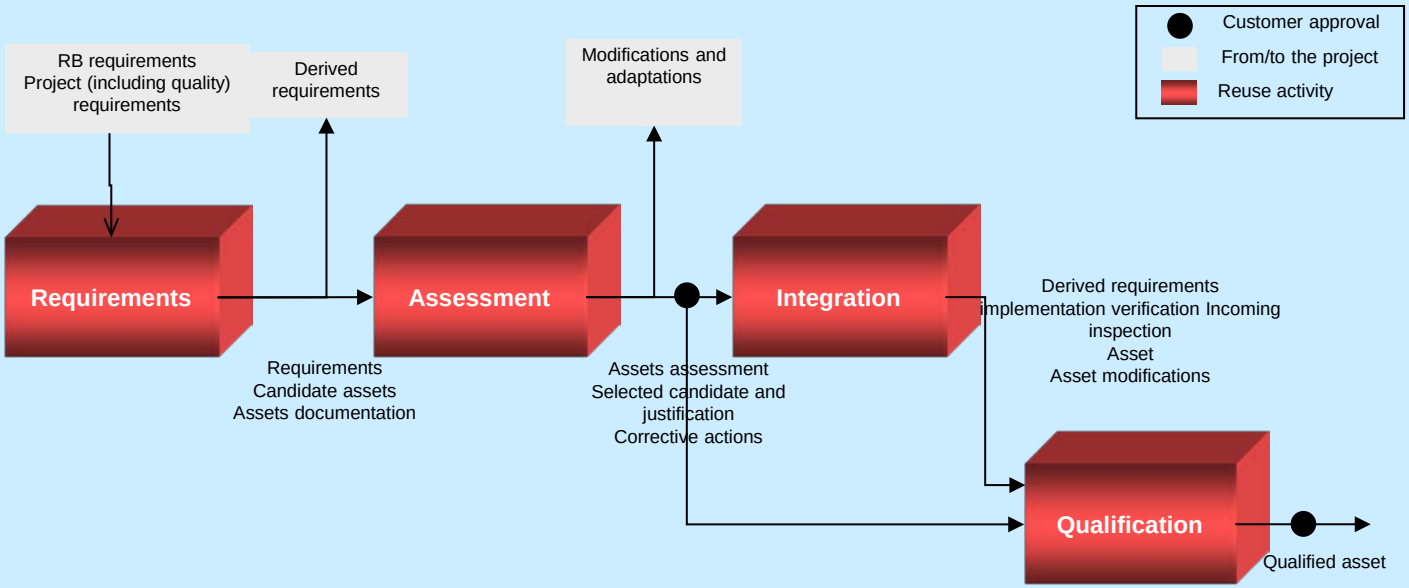
SW reuse approach

- **Phases to be performed for each reused existing software item**



Activities are documented in the SW Reuse File (SRF)

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Software reuse file (SRF)

see also ECSS-E-ST-40C Annex N

1. **Introduction**
2. **Applicable and reference documents**
3. **Terms, definitions and abbreviated terms**
4. **Presentation of existing SW intended to be reused**
   - 4.1 Requirements definition
   - 4.2 Existing SW candidates
5. **Compatibility of existing SW with project requirements**
   - 5.1 Gap analysis
   - 5.2 Derived requirements
6. **Software reuse analysis conclusion**
7. **Detailed results evaluation**

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Software reuse file (SRF)

8. Corrective actions

8.1 Reuse qualification plan

8.2 Reuse qualification results

9. Configuration status

10. Certification aspects (if required)

11. Product service history (when needed)

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Requirements applicable to individual SW engineering processes/activities

Software product assur

5.1 Organization and respo
5.2 Software product assura
programme manageme
5.3 Risk management and
item control

Software process assu

6.1 Software development life cycle
6.2 Requirements applicable to all software engineering processes
6.3 Requirements applicable to individual software engineering processes or activities

Software product quality assurance

7.1 Product quality objectives and metrication
7.2 Product quality requirements
7.3 Software intended for reuse
7.4 Standard ground hardware and services for operational system
7.5 Firmware

6.3.1 Software related system requirements process
6.3.2 Software requirements analysis
6.3.3 Software architectural design and design of software items
6.3.4 Coding
6.3.5 Testing and validation
6.3.6 Software delivery and acceptance
6.3.7 Operations
6.3.8 Maintenance

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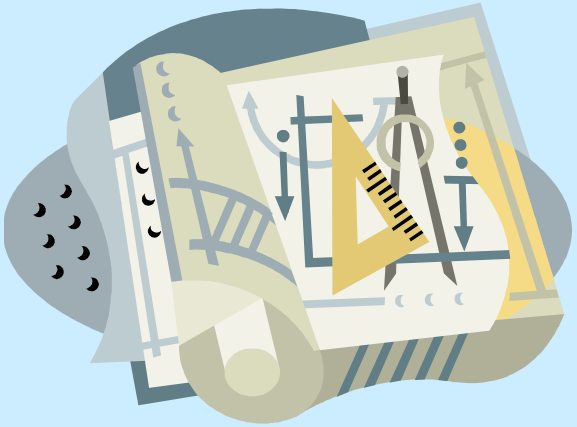
Software related system requirements process

6.3.1.1

- The requirements for this process are defined in ECSS-E-ST-40C, subclause 5.2



6.3.1.2

- The requirement baseline must be kept under configuration control

6.3.1.3

- For the definition of the system requirements applicable to software, the results of the system level safety and dependability analysis must be used

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Software requirements analysis

6.3.2.1

- **The software requirements must be fully and unambiguously defined in the TS**
  - derived from requirement baseline

6.3.2.2

  - using results of RAMS analyses

6.3.2.3

  - kept under configuration control

6.3.2.4

- **Non-functional requirements must be specified**
- **Customer and supplier must agree upon**

6.3.2.5

  - Responsibility for the TS (on both sides)
  - Methods for agreeing on requirements and changes
  - Effort to prevent misunderstandings (e.g. dictionary)

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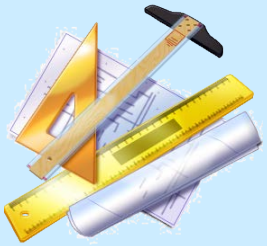
Software architectural design and design of software items

6.3.3.2

6.3.3.3

- **The supplier must define and apply mandatory and advisory design standards**
  - including rules for numerical accuracy



6.3.3.5

- **Means, criteria and tools to ensure that the design meets the quality requirements must be identified**

6.3.3.4

6.3.3.6

- **The supplier must verify and report on the correct applications of design standards**
  - evaluation to be fed back to the design team during the development, for improvement

6.3.3.7

- **The design documentation must be suitable for software maintenance**

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Coding

- **Coding standards must be defined** (6.3.4.1)
  - consistent with the applicable quality requirements
  - to be reviewed with the customer (6.3.4.4)
  - measurements, criteria and tools to verify conformance of source code with coding standards must be defined in the SPAP (6.3.4.3)
- **The supplier must verify and report on the adherence to coding standards** (6.3.4.6)
  - evaluation to be fed back to the programming team during the development, for improvement
- **Use of low-level languages must be justified** (6.3.4.5)
- **Source code under CM control after unit tests** (6.3.4.8)

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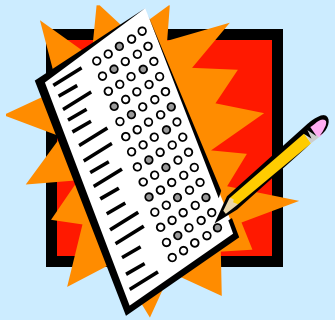
Testing and validation (1/5)

6.3.5.1

- **A testing strategy must be defined and applied**
  - for each testing level (*unit, integration, validation against the technical specification, validation against the requirements baseline, acceptance*)
  - types of tests (e.g. *functional, boundary, performance, usability*)
  - product assurance function involvement

6.3.5.2

- **Test coverage goals must be agreed between customer and supplier**
  - based on criticality of software
  - at different testing level (*unit, integration, etc.*)



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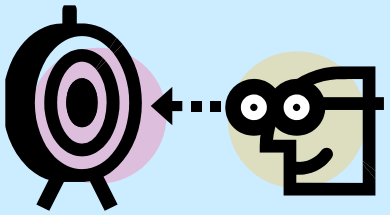
Testing and validation (2/5)

6.3.5

- **Assurance activities for testing**
  - verify suitability, feasibility, traceability, repeatability of tests
  - hold test readiness reviews
  - check achievement of test goals



  - allow for witnessing of test by PA personnel
  - check that the right software configuration is tested according to plans and procedure and documented
  - nonconformances and SPRs must be properly documented
  - completion of actions deriving from testing nonconformances and SPRs must be verified
  - test documentation must be usable for maintenance

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Testing and validation (3/5)

6.3.5.15

- **Regression testing must be performed in case of software modification**
  - documentation must be updated
  - need for regression testing to be evaluated in case of change of platform hardware and code generation tools

6.3.5.16

6.3.5.17

6.3.5.18

6.3.5.19

- **Validation team must be different from development team**

6.3.5.26

- **The software must be validated as a whole product, in an operationally representative environment**

6.3.5.29

- **Test all (or a reasonable number) of the possible software configurations**

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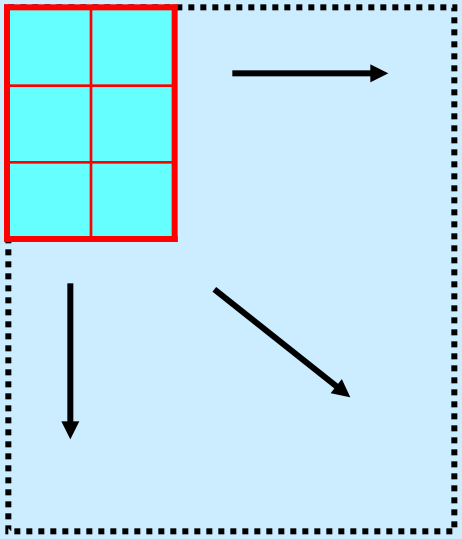
Testing and validation (4/5)

- **Specific validation required for**

6.3.5.30

- deactivated code ⇒ no accidental or harmful activation

```
...
#ifdef DEBUG
  /* deactivated */
#endif
...
```



6.3.5.31

- configurable code ⇒ no unintended configuration included in executable or activated at run-time

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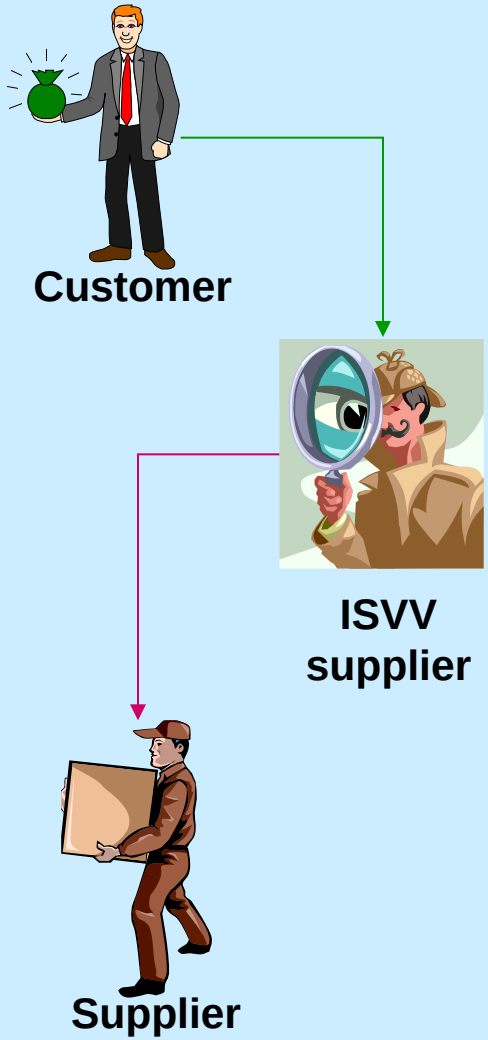
Testing and validation (5/5)

6.3.5.28

- **Independent software validation must be performed by a third party**
- **Applicability and level of independence to be considered based on project risks…**
- **A less rigorous level of independence can be considered (e.g. independent team in the same organization)**



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Software delivery and acceptance (1/2)

6.3.6

- **Installation procedure to be produced**
  - defining roles and responsibilities on both sides
- **Acceptance test plan established by the customer**
  - tests from previous phases can be reused
- **The supplier must**
  - ensure that the delivered software meets the contractual requirements
  - the source and object code are the right ones
  - agreed changes are implemented
  - NCRs are either resolved or declared

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Software delivery and acceptance (2/2)

6.3.6

- **Problems during acceptance must be documented in NCRs**
- **The customer must ensure that**
  - the executable is generated from controlled code and installed according to installation procedures
  - the tests are executed in accordance with the plan
- **An acceptance report must be produced and signed by both parties**
- **The customer shall state the acceptance tests result (accepted, conditionally accepted, rejected)**

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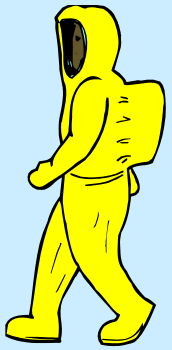
Operations

6.3.7

- **During operations, the quality of the mission products related to software must be agreed upon**
- **Validation of the operational requirements**
  - availability and maintainability
  - safety features
  - HMI
  - operational procedures
  - conformance to quality requirements



- **Product assurance plan for operations must consider software operations**

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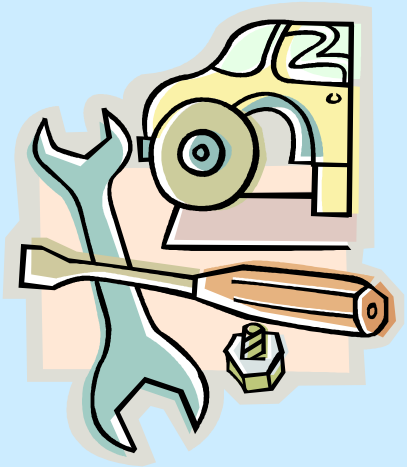
Maintenance

6.3.8

- **The maintenance organization must be identified early in the life cycle**
- **A maintenance plan must be produced**
  - scope of maintenance
  - activities
  - quality measures
  - reporting, …
- **Records must be generated for each maintenance activity**
  - problems
  - responsibilities
  - solutions, …



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Software Product Quality Assurance

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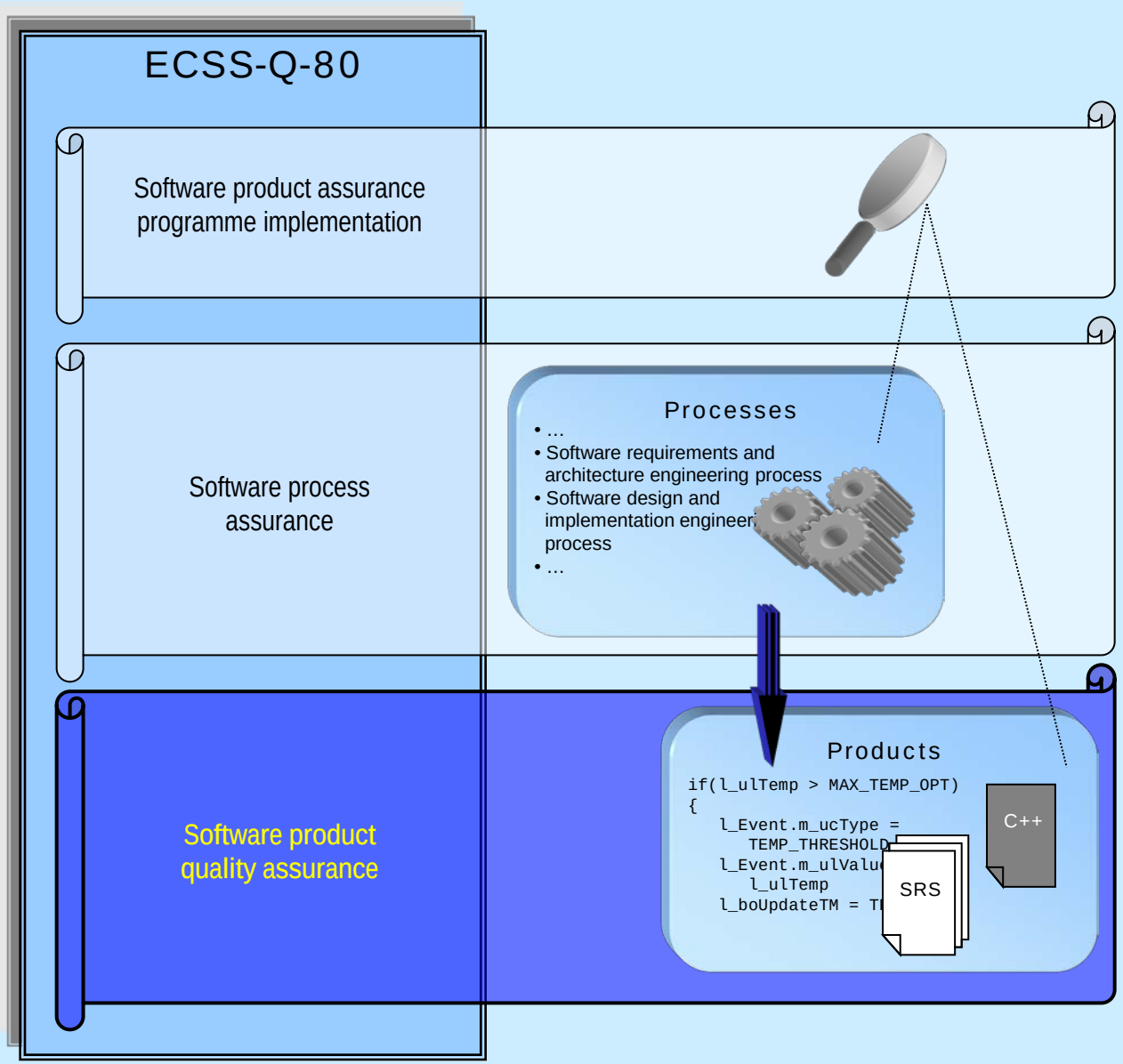
Ensuring the quality of the product

Clause 7



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Product quality objectives and metrication *(already covered)*

Software product assurance programme implementation

5.1 Organization and responsibility
5.2 Software product assurance
progra
5.3 Risk ma
item co
5.4 Supplier selection and control
5.5 Procurement

Software p

6.1 Softwar
6.2 Require
6.3 Require
or activ

7.1.1 Deriving of requirements
7.1.2 Quantitative definition of quality requirements
7.1.3 Assurance activities for product quality requirements
7.1.4 Product metrics
7.1.5 Basic metrics
7.1.6 Reporting of metrics
7.1.7 Numerical accuracy
7.1.8 Analysis of software maturity

Software product quality assurance

7.1 Product quality objectives and metrication
7.2 Product quality requirements
7.3 Software intended for reuse
7.4 Standard ground hardware and services for operational system
7.5 Firmware

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Product quality requirements

Software product assurance programme implementation

- 5.1 Organization and responsibility
- 5.2 Software product assurance programme management
- 5.3 Risk management and critical item control
- 5.4 Supplier selection and control
- 5.5 Procurement
- 5.6 Tools and supporting environment
- 5.7 Assessment and improvement process

Software process assurance

- 6.1 Software development life cycle
- 6.2 Require
- 6.3 Require or activ

Software product quality assurance

- 7.1 Product quality objectives and metrication
- 7.2 Product quality requirements
- 7.3 Software intended for reuse
- 7.4 Standard ground hardware and services for operational system
- 7.5 Firmware

- 7.2.1 Requirements baseline and technical specification
- 7.2.2 Design and related documentation
- 7.2.3 Test and validation documentation

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Requirements baseline and technical specification

7.2.1.1

- **Software quality requirements must be documented in RB and TS**

7.2.1.2

- **Software requirements must be**
  - correct
  - unambiguous
  - complete
  - consistent
  - verifiable
  - traceable

7.2.1.3

- **For each requirement the method for verification and validation shall be specified.**

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Design and related documentation

7.2.2

- **The software design must meet non-functional requirements**
- **The software design must facilitate testing**
- **Software with a long lifetime must be designed so to be independent from operating system and hardware**
  - Potential obsolescence and non-availability of operational environment

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Test and validation documentation

7.2.3

- **The test documentation must**
  - cover test environment, tools, personnel, training needs
  - criteria for test completion and contingency steps
  - test procedures, data and expected results
  - hardware and software configuration
- **For any requirements not covered by testing, a report must be produced to document the verification activities performed**

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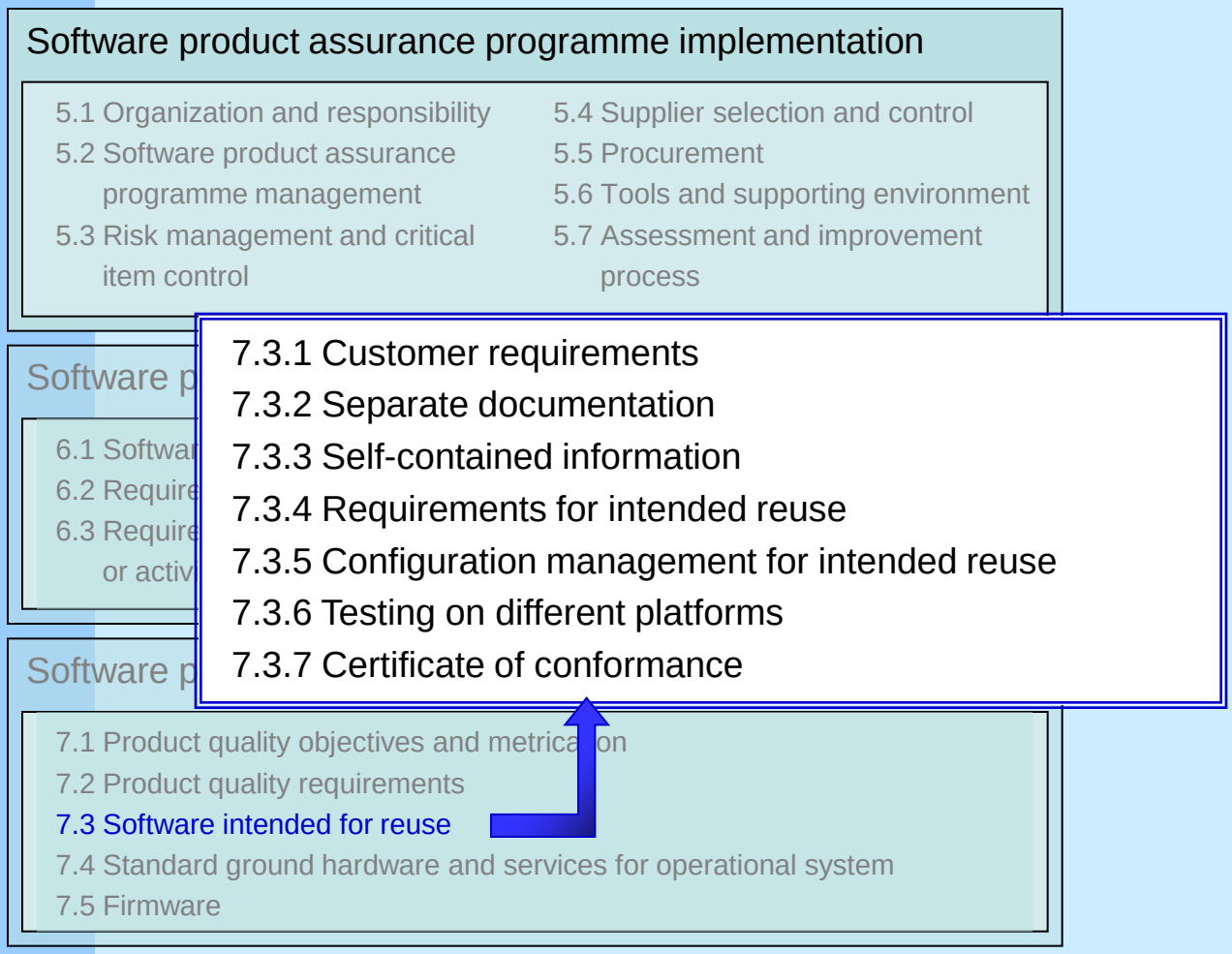
Software intended for reuse



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Software intended for reuse

7.3

- **The documentation of software intended for reuse in the technical specification design justification file, design definition file and product assurance file must be**
  - separated from the other
  - self-contained
- **Requirements for maintainability, portability and verification in TS**
- **Specific configuration management**
- **Testing on all target platforms**

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Standard ground hardware and services for operational system

Software product assurance programme implementation

- 5.1 Organization and responsibility
- 5.2 Software product assurance programme management
- 5.3 Risk management and critical item control
- 5.4 Supplier selection and control
- 5.5 Procurement
- 5.6 Tools and supporting environment
- 5.7 Assessment and improvement process

Software process assurance

- 6.1 Software development life cycle
- 6.2 Require
- 6.3 Require or activ

Software p

- 7.1 Produc
- 7.2 Product quality requirements
- 7.3 Software intended for reuse
- 7.4 Standard ground hardware and services for operational system
- 7.5 Firmware

- 7.4.1 Hardware procurement
- 7.4.2 Service procurement
- 7.4.3 Constraints
- 7.4.4 Selection
- 7.4.5 Maintenance

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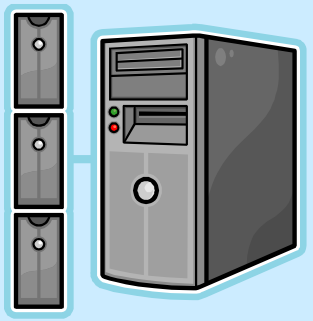
Standard ground hardware and services for operational system

7.4

- **Procurement of operational hardware to be made in accordance with ECSS-Q-ST-20C, subclause 5.4 (typo)**
- **Justification of procurement of operational services must be provided**
- **Selection of hardware and services based on specified criteria and taking into account development and operational constraints**
- **Maintenance of the operation hardware and services must be ensured throughout the entire software operational life**



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Standard ground hardware and services for operational system

Software product assurance programme implementation

- 5.1 Organization and responsibility
- 5.2 Software product assurance programme management
- 5.3 Risk management and critical item control
- 5.4 Supplier selection and control
- 5.5 Procurement
- 5.6 Tools and supporting environment
- 5.7 Assessment and improvement process

Software process assurance

- 6.1 Software development life cycle
- 6.2 Requirements applicable to all software engineering processes
- 6.3 Requirements applicable to individual software engineering processes or activities

Softw

- 7.1 P
- 7.2 P
- 7.3 Software intended for reuse
- 7.4 Standard ground hardware and services for operational system
- 7.5 Firmware

7.4.1 Device programming
7.4.2 Marking
7.4.3 Calibration

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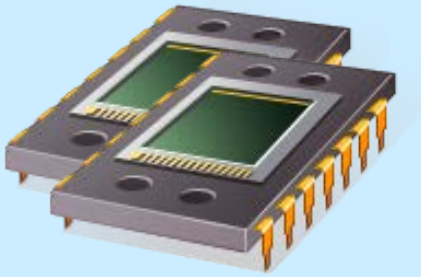
Firmware

7.5

- The supplier must establish procedures for firmware device programming and duplication of firmware devices.



- Firmware devices must be marked for the identification of the hardware and software
- Firmware programming equipment must be calibrated

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Questions?

JUST ONE BUG MAY BE ENOUGH …