



**中国航天标准化研究所**

China Astronautics Standards Institute



# **Space Product Assurance in China**

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# PRESENTATION OUTLINE

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**PA RESOURCES AND ORGANIZATIONS**

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**PA OF BASIC PRODUCTS FOR SPACE USE**

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**CONCLUDING REMARKS**



- Product Assurance (PA)
  - A series of technical and management activities
  - Performed in a planned and organized manner
  - To assure that the product conforms to specified quality requirements
- PA activities
  - PA management
  - Quality Assurance (QA)
  - Reliability, Maintainability and Safety (RMS) assurance
  - Software product assurance
  - EEE parts assurance
  - Parts, Materials, and Processes (PMP) assurance

- PA management
  - Identification of responsibilities and authorities
  - Construction of the quality responsibility system
  - Establishment of PA organizations
  - Construction of PA resources, including personnel, standards, testing analysis laboratories, etc.
  - Control on critical products and processes,
  - Planning, implementation, control and audit of the PA program

# INTRODUCTION

- Product Assurance in China space industry
  - Initiated in the early 1990s
  - The technical and managerial framework of PA characteristic of China space industry
    - Prevention
    - Source management
    - Whole process control
    - Systematic management
- Quality Promotion Program of CASC
  - Personnel training
  - Infrastructure construction
  - Standard system construction
  - Critical items control



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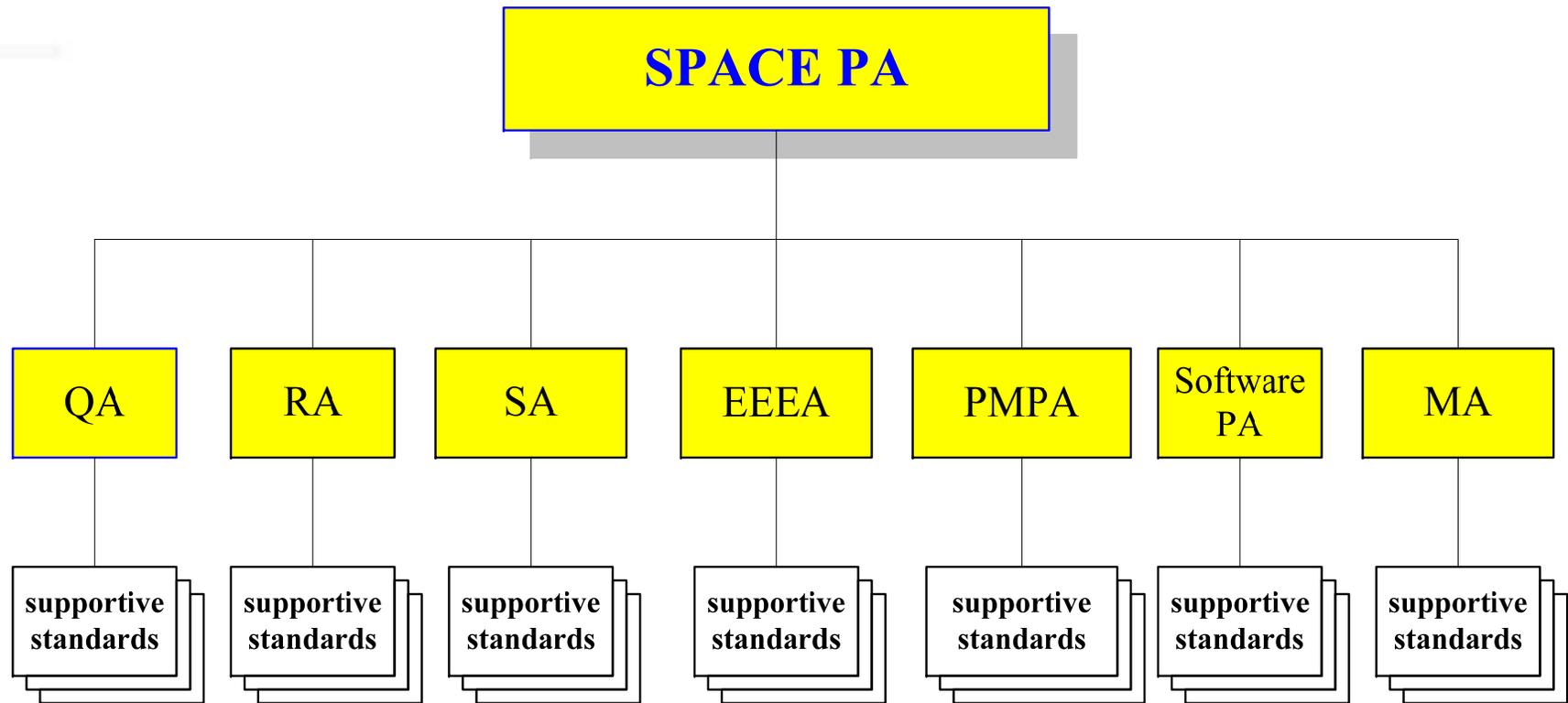
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CONCLUDING REMARKS



# PRODUCT ASSURANCE STANDARDS



*China Space PA Standard System*

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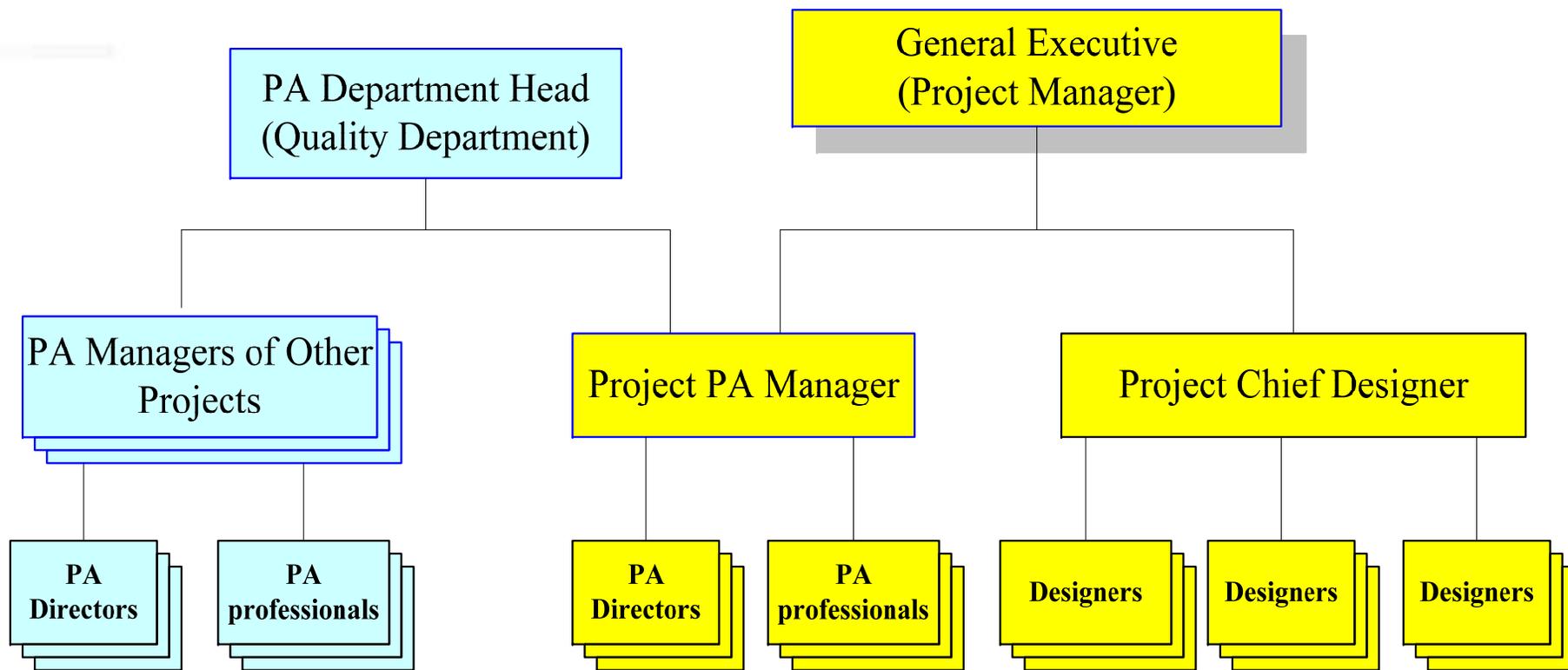
**7** CONCLUDING REMARKS



# PA RESOURCES AND ORGANIZATIONS

- Investment of construction and renewal of technical facilities
- Professional organizations
  - Reliability and Safety Research Center
  - Quality and Reliability Information Center
  - Components Reliability Center
  - Material Testing and Failure Mechanism Analysis Center
  - Software Testing and Evaluation Center and several Software Testing and Evaluation Stations
  - Environmental Reliability Testing Center for Space Products
  - Environmental Reliability Testing Center for Launch Vehicles
  - Quality System Certification Body
  - Space Standardization Research and Consulting Center
  - Process Research Center, etc.

# PA RESOURCES AND ORGANIZATIONS



*PA In a specific space project*



# PA RESOURCES AND ORGANIZATIONS

- Functions of PA (quality management) department
  - From “pure management” into “technical research and management”
  - Safety & reliability development and applications
  - Parts, materials and processes control
  - Product inspections and tests
  - Technical support of reliability and safety methodology and tools
  - Quality audit
  - Quality and reliability database management
  - The establishment of related standards, specifications and manuals, etc.



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- RMS Assurance in Brief
  - RMS assurance tasks
    - Assignment of professional RMS engineers
    - Establishment of operational and checkable RMS work plan
    - Stipulation of forceful minimum RMS engineering tasks in every development stage of the program
    - Strict audit and conformance evaluation of the above reliability tasks

- RMS Assurance in Brief
  - Maintainability Assurance
    - Maintainability Program
    - Maintainability Design Criteria
    - Maintainability Reviews
  - Safety Assurance
    - Safety Program
    - Hazard Analysis
    - Safety Reviews

- Reliability Requirements
  - Specified as early as possible
  - Clear and verifiable definitions
  - Include both qualitative and quantitative
  - Be decomposed hierarchically
  - Stipulate specific reliability related work requirements
  - Lessons learned
    - Incomplete and indistinct requirements are the initial sources that result in engineering risks

- Reliability Program

- *“Requirements of reliability assurance of space products”*
  - General reliability program for reliability assurance
  - Consists of all related tasks in the whole life cycle
  - Include reliability objects, tasks, work requirements, phase descriptions, critical review points, label of accomplishment, etc.
  - Reliability assurance activities are classified into 3 categories and totally 17 tasks
  - Low-level standards are developed to support the implementation
  - Guideline of tailoring supplied



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- Backgrounds

- Product assurance for complex space systems cannot rely solely on the so-called reliability tasks as in standards
- China's developing industry infrastructure
- Incisive PA measures must be considered for special products, special processes, and tuned to special social environments and industry
- Major difficulties are on basic products, such as EEE components, software, parts, materials and processes

- Electric, Electronic, and Electro-mechanical (EEE) Parts
  - *Five Centralized Activities*
    - *Centralized selection*
    - *Centralized purchasing*
    - *Centralized local manufacturing supervision and acceptance*
    - *Centralized screening and re-validation*
    - *Centralized failure mechanism analysis*

- To support Five Centralized Activities for EEE Parts
  - Technical supportive organizations
    - Expert Board for Space EEE Parts (EBSEP)
    - Research centers for EEE parts
    - Parts Testing and Failure Analysis Center (PTFAC)
  - Standards and stipulations
    - *Quality Management Stipulations of Space EEE Parts*
    - *Requirements of Space EEE Parts Assurance*
    - *Derating Criteria of EEE Parts for Reliability*
    - *Selection Management Requirement of EEE Parts*
    - *Preferred EEE parts List, etc.*
  - Destructive Physical Analysis (DPA)

- Computer Software
  - Growing quantities and the increasing importance
  - Promote software engineering
  - Requirement analysis, implementation and test strictly separated
  - Indoor Tests (static and dynamic)
  - Independent Validation Test (VT) for all Class A and Class B software modules

- Parts, Materials, and Processes (PMPs)
  - Selection control of PMPs
    - General selection guidelines
    - Handbook or name list of preferred PMPs;
    - Project-specific control list of PMPs
  - Additional Verification Test and Control (AVTC)
    - Newly introduced PMPs
    - Matured PMPs used to varied conditions
  - Control of purchasing process
  - Failure analysis and failure alarming system



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# CONTROL OF DESIGN PROCESS AND MANUFACTURING PROCESS

- Management of Design Configurations
  - Strict control of design configurations
    - Stipulations of auditing and signing, issuing, and documentation
    - Modifications and alterations of design configurations strictly controlled
    - Tabulated control sheets
      - *Application Sheet for Configuration Modification*
      - *Notification Sheet of Modifications*
      - *Request Sheet for Technological Coordination*
      - *Process Sheet of Technological Issues*

- Two Kinds of Design Reviews
  - Design reviews on critical points
    - Conceptual design
    - Sub-system design
    - Critical devices
    - Launch release, etc.
  - Design reviews on special topics
    - Reliability and safety
    - Software
    - Critical process
    - Parts and components, etc.

# CONTROL OF DESIGN PROCESS AND MANUFACTURING PROCESS

- The Three F's of Reliability Analysis Tools
  - Failure Modes, Effects and Criticality Analysis (FMECA)
  - FTA (Fault Tree Analysis)
    - For fatal or critical system failure modes (Criticality category I and II in FMECA)
  - FRACAS (Failure Reporting, Analysis, and Corrective Action System)
    - Failure reporting
    - Failure analysis
    - Failure correction

# CONTROL OF DESIGN PROCESS AND MANUFACTURING PROCESS

- The Four Re's
  - **Re-check** for important failures occurred
  - **Re-audit** by peer experts for critical designs
  - **Re-validation** in selection and use of important materials (metal, non-metal, soldering materials, etc.)
  - **Re-calculation** of important performance parameters

# CONTROL OF DESIGN PROCESS AND MANUFACTURING PROCESS

- The Double Five Rules of Close (DFRC)
  - Closes of quality concerns
    - Complete elimination of quality concerns (failures, faults, defects, abnormalities, etc.)
    - Whenever they occur
    - By means of a series of activities including analysis of causes and mechanisms, corrective and preventing measures
    - Aiming at preventing the similar problems from repetitive occurring

- Five Rules of Technical Close (FRTC)
  - Accurate localization of the failure causes, distinguishing the inherent cause from dependent failures
  - Explicit illustration of failure mechanisms
  - Reveal of the same failure phenomenon under recognized failure causes and mechanisms (through revealing test or simulation)
  - Demonstration of the effectiveness of corrective actions (through demonstration test or simulation)
  - Drawing inferences from the lessons learned to more general cases used for other similar occasions or other systems within or beyond the project

# CONTROL OF DESIGN PROCESS AND MANUFACTURING PROCESS

- Five Rules of Managerial Close (FRMC)
  - **Explicit explanation** of the developing and propagating of failures from the administrative point of view
  - **Responsibility decomposed** down to every administrative level
  - **Corrective or compensating actions implemented** for the occurred failures
  - **Economic punishment** for the responsible bodies and personnel
  - **Stipulations modified or incremented** to avoid the repetitive failures

# CONTROL OF DESIGN PROCESS AND MANUFACTURING PROCESS

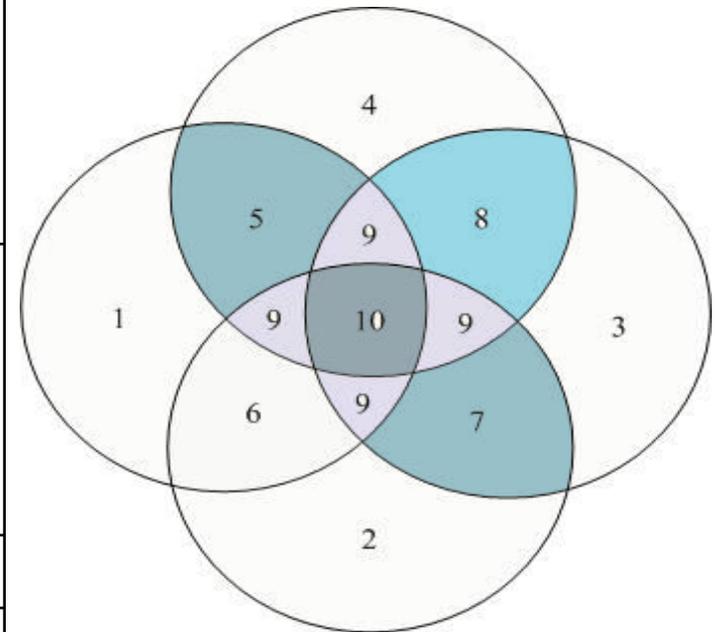
- Intersection Based Risk Analysis Method of Quality Concerns
  - Four major risk sources
    - Failures or Faults Occurred in History
    - Modifications of Configurations Exist
    - Detection Impossible for Some Items
    - Inherent Single Point Failures
  - Combinations of the risk sources

# CONTROL OF DESIGN PROCESS AND MANUFACTURING PROCESS

Table 1. Risk Ratings versus Risk Sources

No.	Types of Quality Concerns	Risk Rating
1	① Failures or Faults Occurred in History	IV
2	② Modifications of Configurations Exist	
3	③ Detection Impossible for Some Items	
4	④ Inherent Single Point Failures	
5	①+④	III
6	①+②	
7	②+③	
8	③+④	
9	①+②+③, ②+③+④, ①+②+④, ①+③+④	II
10	①+②+③+④	I

Figure 2. Depiction of Intersection Based Risk Analysis



# CONTROL OF DESIGN PROCESS AND MANUFACTURING PROCESS

- Control of Manufacturing Process
  - Continuing improvement of the manufacturing facilities
  - Continuing improvement of the working standards
  - Recommendation of non-destructive detection practices
  - Mechanism of refusal of acceptance and funding between users and contractors
  - Establishment and implementation of the “Pass” criteria at key stages
  - Establishment of product quality history records for traceability

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## CONCLUDING REMARKS

- Many lessons had been learned .....
- The contents of space product assurance enriched.....
- Creative PA measures adopted which make full considerations of Chinese industry infrastructure
- The successes of China space programs in recent years verified the effectiveness of the PA system and the practicality of the relevant methodology
- Still developing.....

# Thanks for Attention

