RELIABILITY AND QUALITY ASSURANCE PROGRAM FOR SPACE MISSIONS-INDIAN SCENARIO

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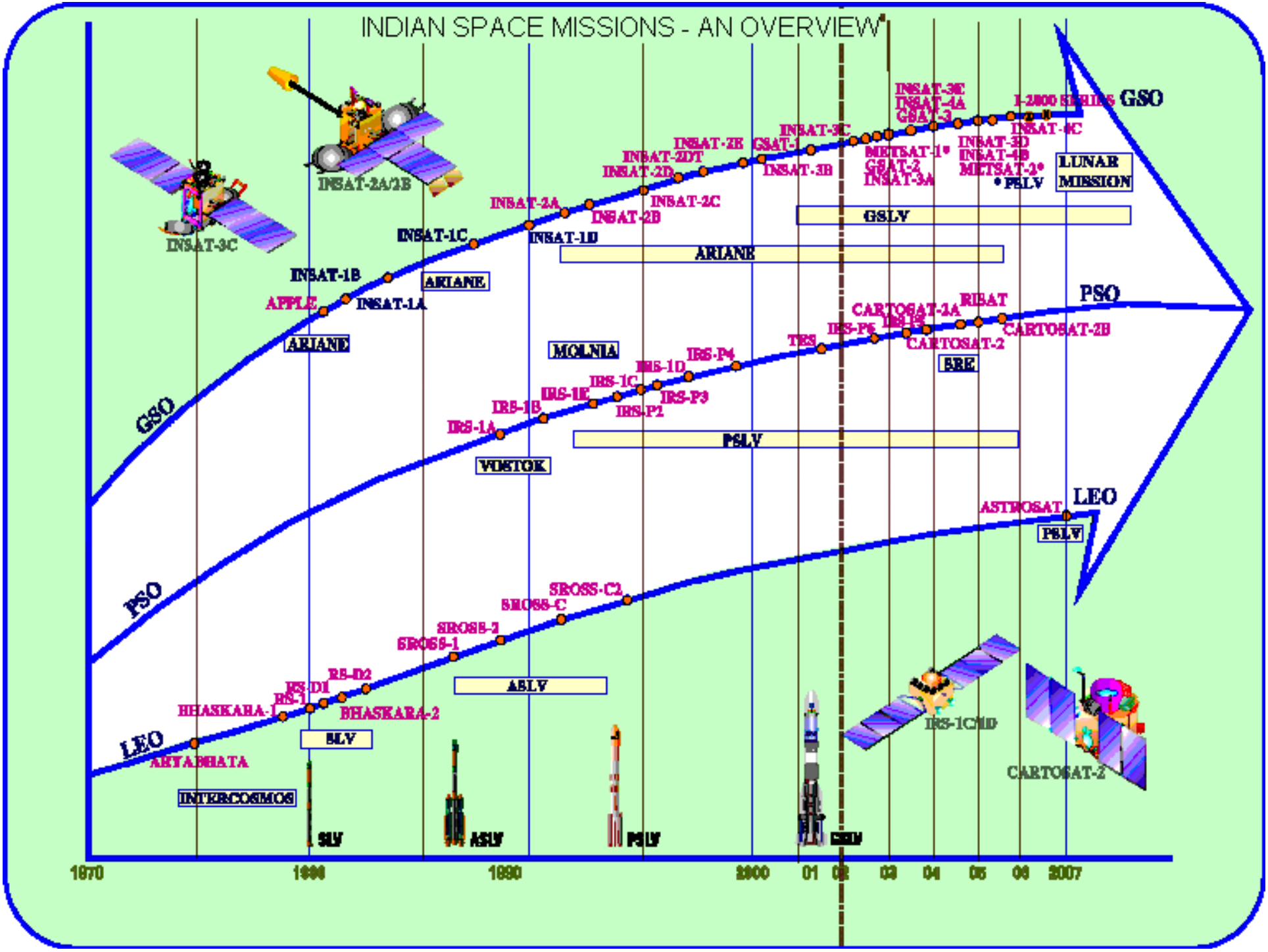
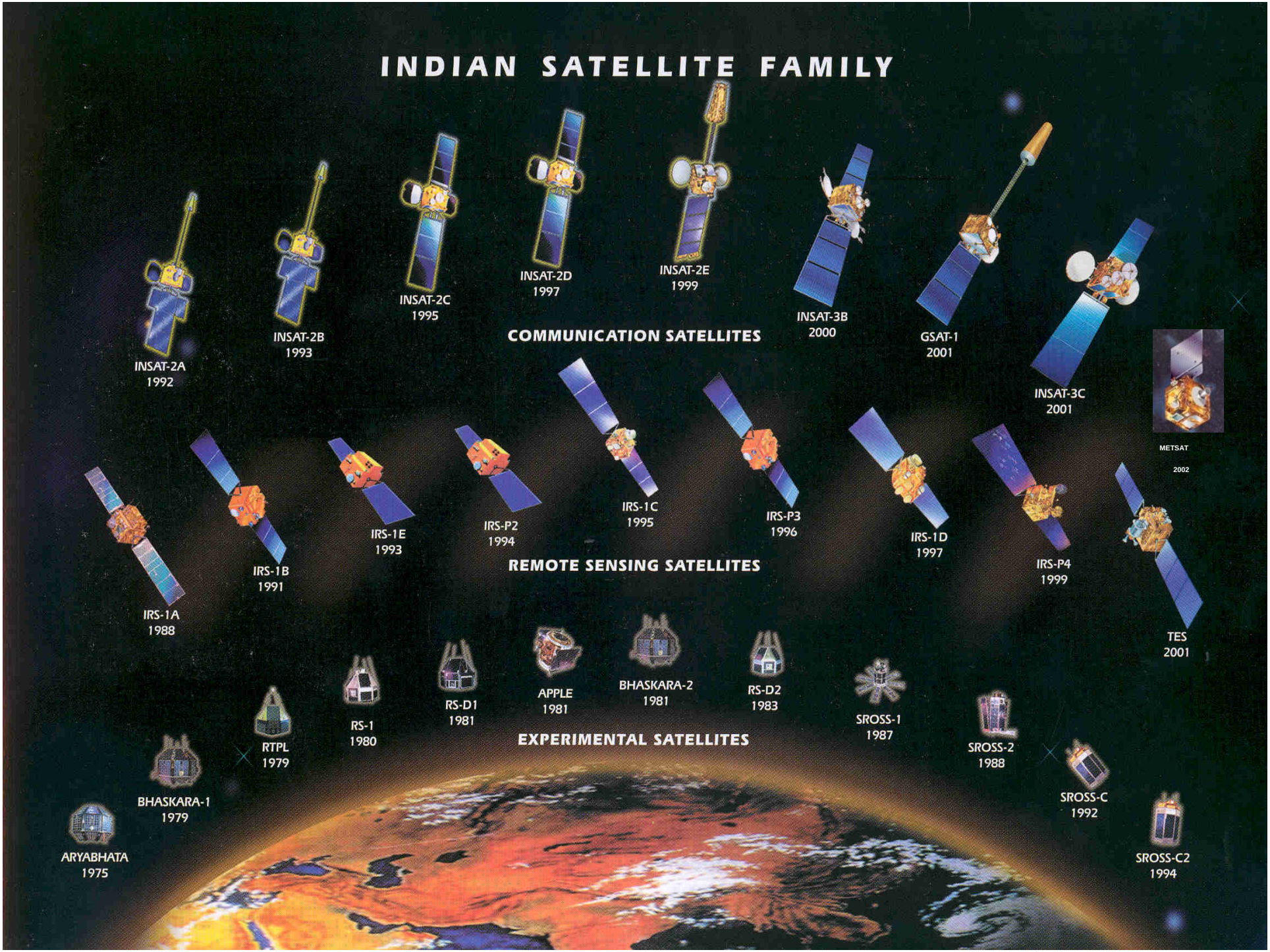
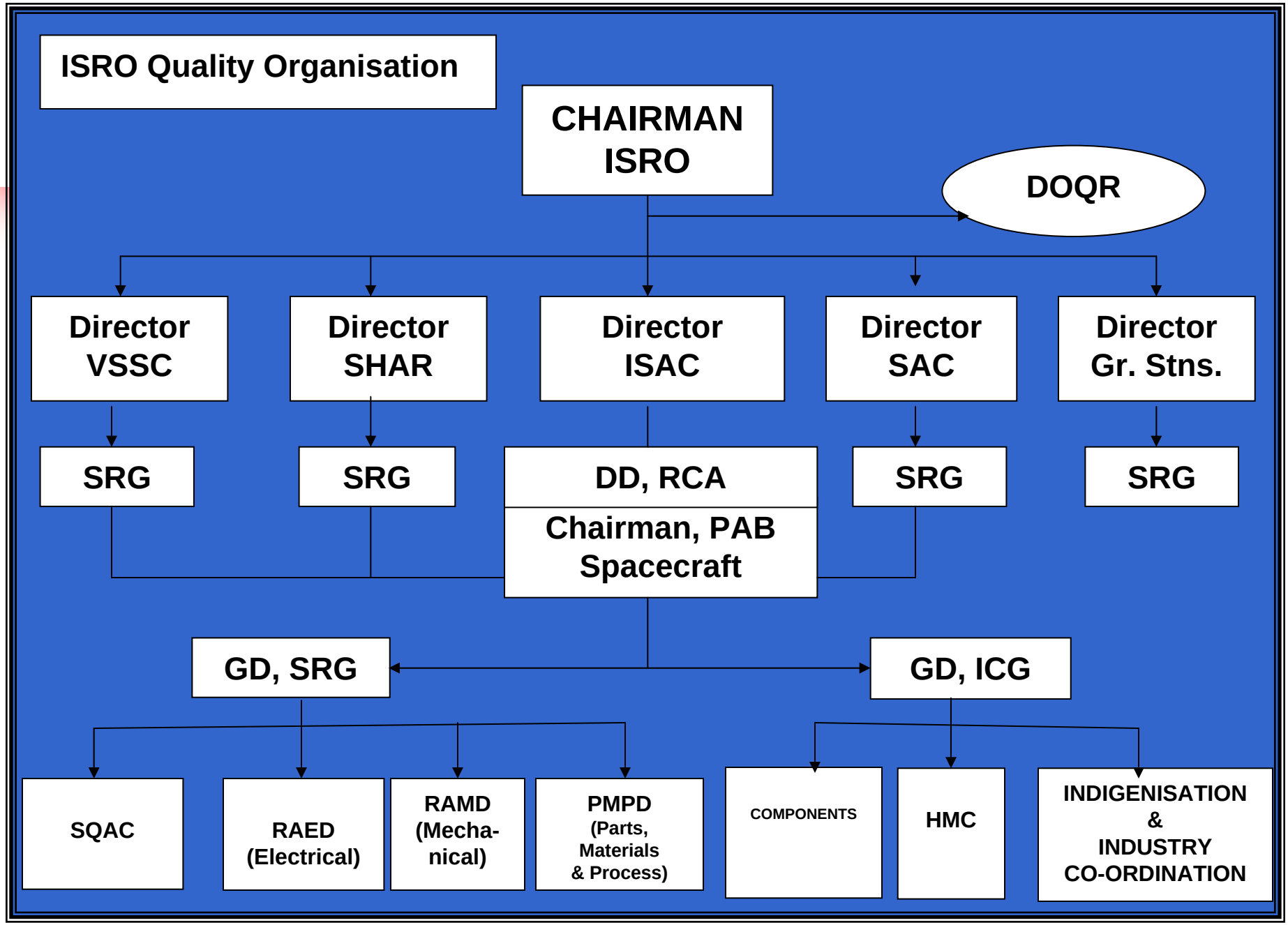
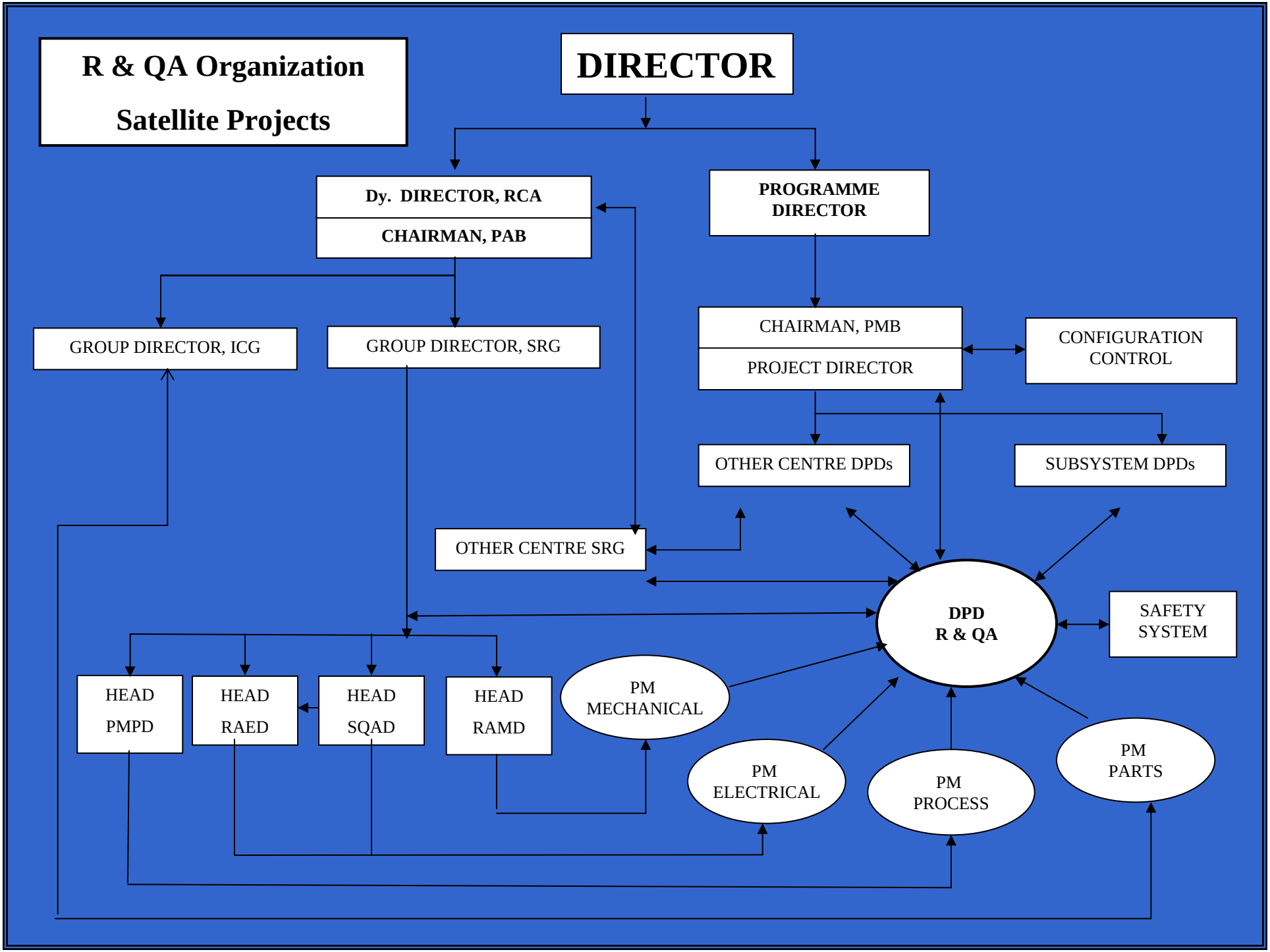

INDIAN SPACE MISSIONS - AN OVERVIEW
GSO
PSO
LEO
INSAT-3C
INSAT-2A/2B
INSAT-3E
INSAT-4A
GSAT-3
I-2000 SERIES
INSAT-4C
INSAT-3D
INSAT-4B
METSAT-2*
* PSLV
LUNAR MISSION
INSAT-2E
GSAT-1
INSAT-3C
INSAT-2DT
INSAT-2D
INSAT-3B
METSAT-1*
GSAT-2
INSAT-3A
INSAT-2A
INSAT-2B
INSAT-2C
INSAT-1D
GSLV
INSAT-1C
ARIANE
INSAT-1B
INSAT-1A
APPLE
ARIANE
CARTOSAT-2A
RISAT
CARTOSAT-2B
IRS-P5
IRS-P6
CARTOSAT-2
TES
SRE
MOLNIA
IRS-P4
IRS-1D
IRS-1C
IRS-1E
IRS-P3
IRS-P2
IRS-1B
IRS-1A
PSLV
VOSTOK
ASTROSAT
PSLV
SROSS-C2
SROSS-C
SROSS-2
SROSS-1
RS-D2
RS-D1
RS-1
BHASKARA-1
BHASKARA-2
ASLV
SLV
ARYABHATA
INTERCOSMOS
IRS-1C/1D
CARTOSAT-2
SLV
ASLV
PSLV
GSLV
1970
1980
1990
2000
01
02
03
04
05
06
2007


INDIAN SATELLITE FAMILY
INSAT-2A 1992
INSAT-2B 1993
INSAT-2C 1995
INSAT-2D 1997
INSAT-2E 1999
INSAT-3B 2000
GSAT-1 2001
INSAT-3C 2001
COMMUNICATION SATELLITES
METSAT 2002
IRS-1A 1988
IRS-1B 1991
IRS-1E 1993
IRS-P2 1994
IRS-1C 1995
IRS-P3 1996
IRS-1D 1997
IRS-P4 1999
TES 2001
REMOTE SENSING SATELLITES
ARYABHATA 1975
BHASKARA-1 1979
RTPL 1979
RS-1 1980
RS-D1 1981
APPLE 1981
BHASKARA-2 1981
RS-D2 1983
SROSS-1 1987
SROSS-2 1988
SROSS-C 1992
SROSS-C2 1994
EXPERIMENTAL SATELLITES


ISRO Quality Organisation
CHAIRMAN ISRO
DOQR
Director VSSC
Director SHAR
Director ISAC
Director SAC
Director Gr. Stns.
SRG
SRG
DD, RCA
Chairman, PAB Spacecraft
SRG
SRG
GD, SRG
GD, ICG
SQAC
RAED (Electrical)
RAMD (Mecha-nical)
PMPD (Parts, Materials & Process)
COMPONENTS
HMC
INDIGENISATION & INDUSTRY CO-ORDINATION


R & QA Organization
Satellite Projects
DIRECTOR
Dy. DIRECTOR, RCA
CHAIRMAN, PAB
PROGRAMME DIRECTOR
GROUP DIRECTOR, ICG
GROUP DIRECTOR, SRG
CHAIRMAN, PMB
PROJECT DIRECTOR
CONFIGURATION CONTROL
OTHER CENTRE DPDs
SUBSYSTEM DPDs
OTHER CENTRE SRG
DPD R & QA
SAFETY SYSTEM
HEAD PMPD
HEAD RAED
HEAD SQAD
HEAD RAMD
PM MECHANICAL
PM ELECTRICAL
PM PROCESS
PM PARTS

R & QA – MAJOR DISCIPLINES

- Design Assurance
- Reliability Assurance
- Parts, Materials and Process Control
- Test and Evaluation
- Software Assurance
- Non-Conformance Management
- Configuration Control

DESIGN ASSURANCE

- Analysis
  - Worst Case Circuit Analysis
  - Mechanical Analysis
  - Thermal Analysis
  - EMI/EMC Analysis
- Reviews
  - Design/Development Phase
  - Prototyping
  - Deliverable Phase

Domain Specialists from scientific institutions/academia are involved in the review process to facilitate 'peer views'

RELIABILITY ASSURANCE

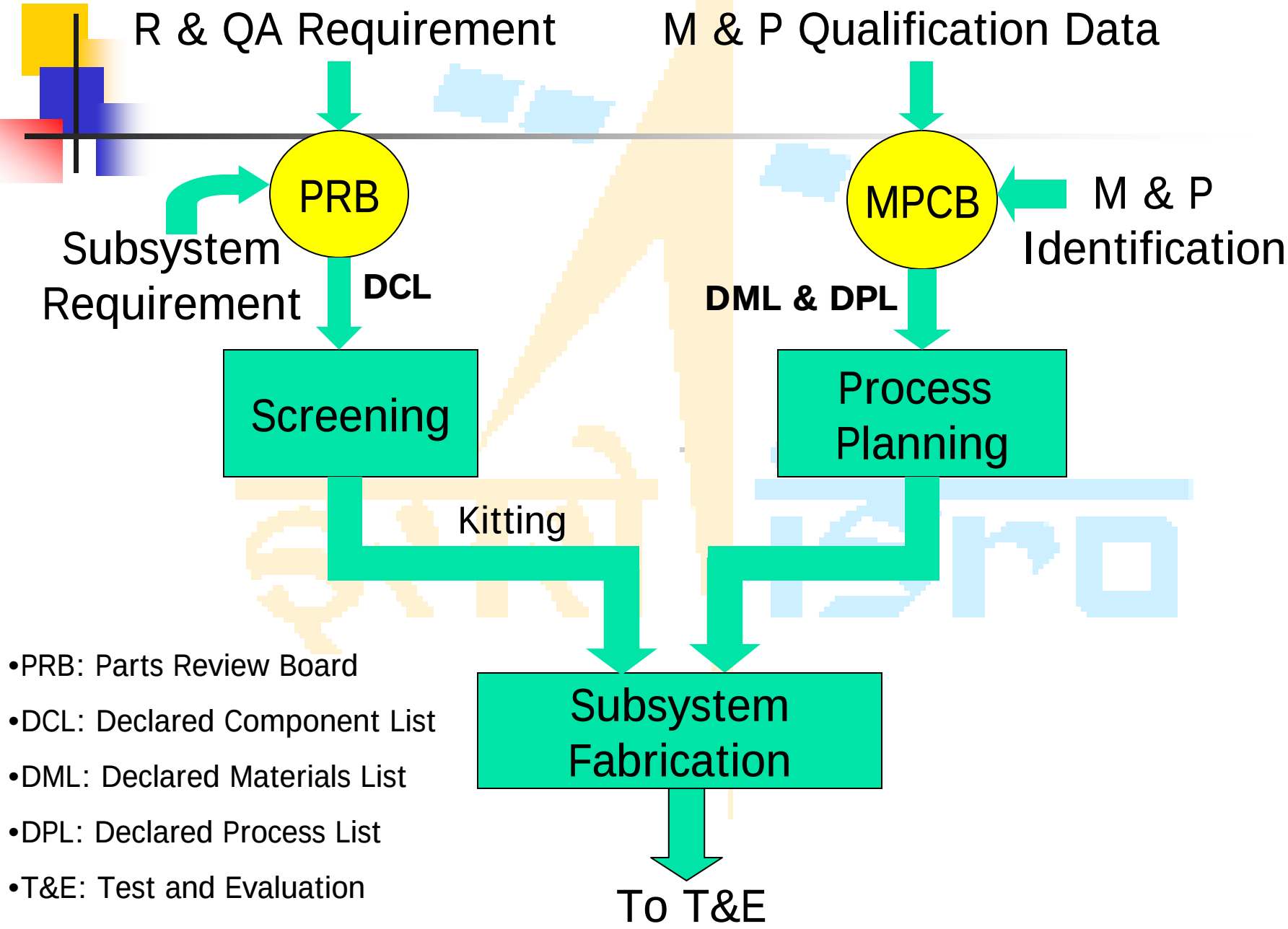
- Reliability Analysis
  - FMEA/FTA
  - Stress Derating
  - Estmation/Assessment

  Uses ISRO experience along with industry standards for guidelines

- Test and Evaluation
  - Functional performance
  - Environmental Sustenance
  - ReliabilityTests

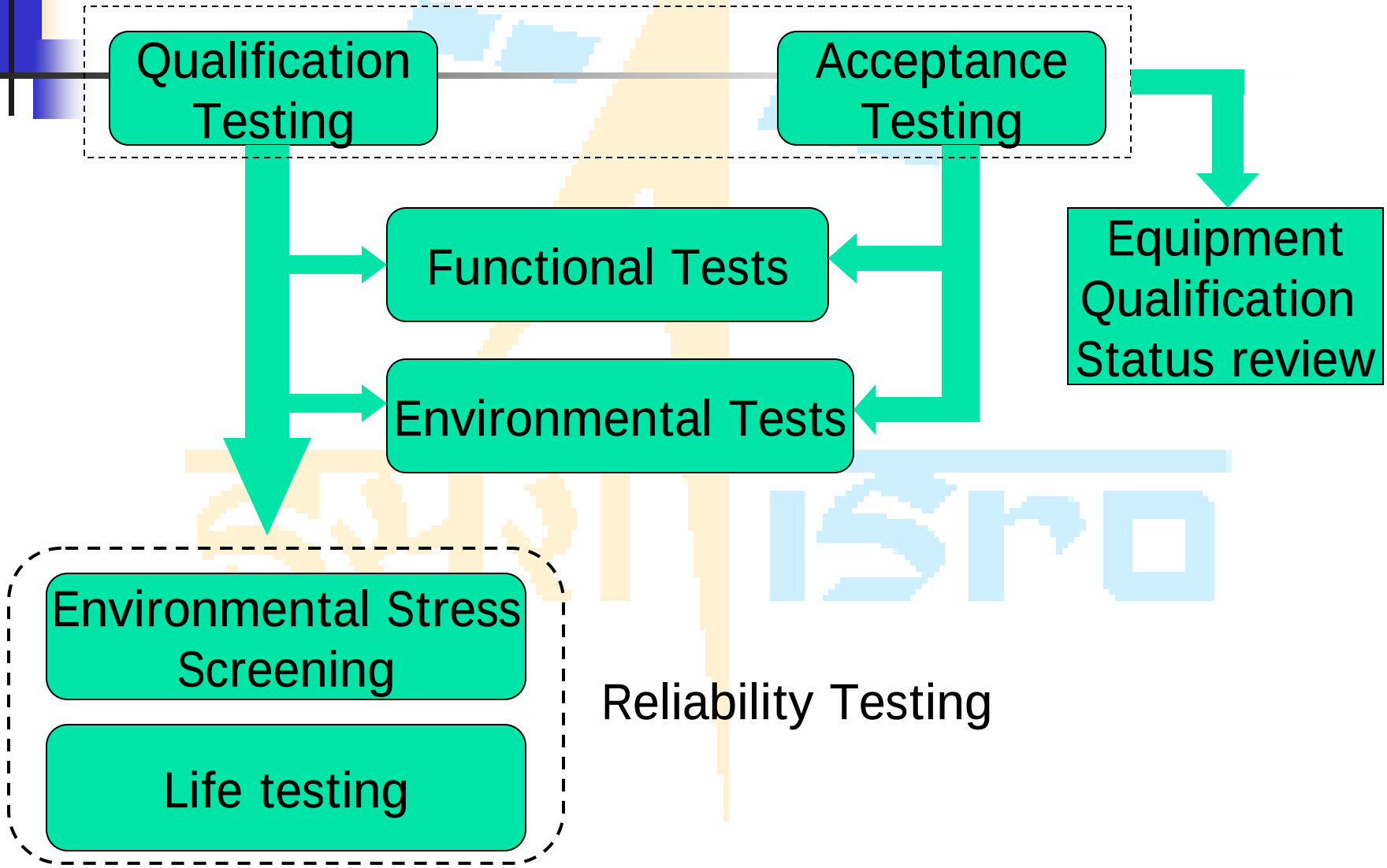
  Complete range of required facilities under 'one roof' to carry out tests at different levels of hardware maturity

Parts material & Process



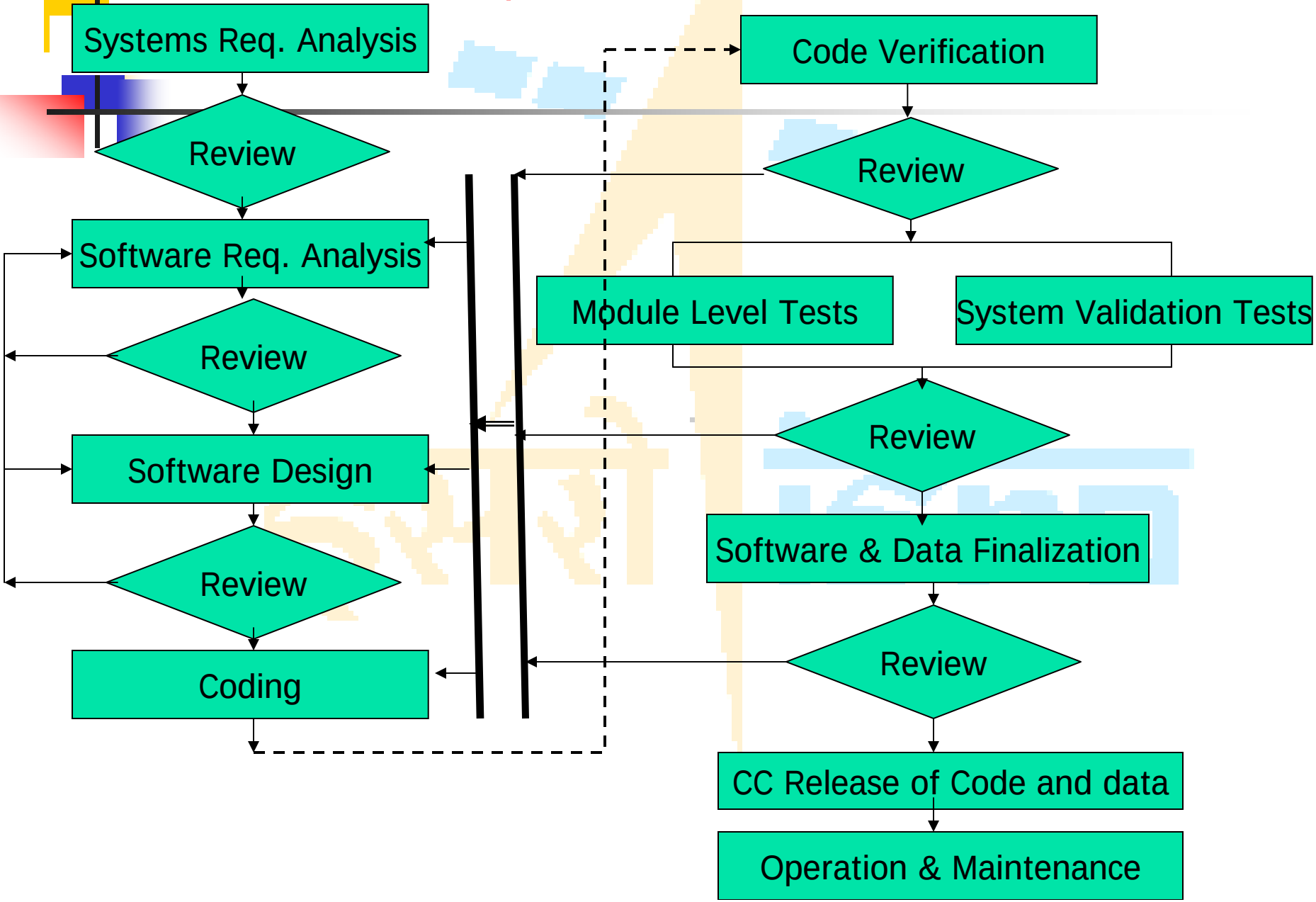
- PRB: Parts Review Board
- DCL: Declared Component List
- DML: Declared Materials List
- DPL: Declared Process List
- T&E: Test and Evaluation

TEST & EVALUATION

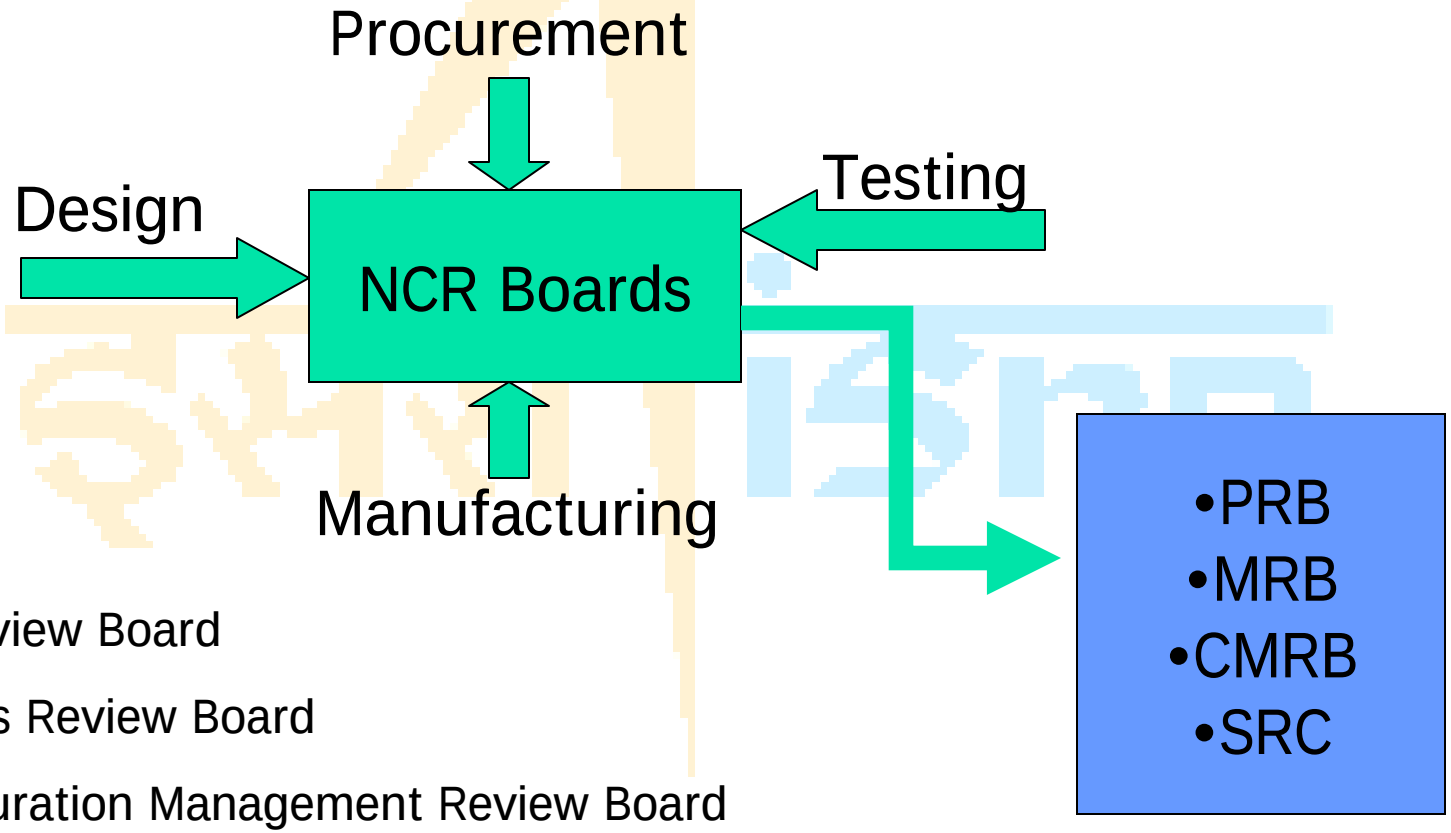


On-Board Software

Sequence Of Activities



Non-Conformance Management



- PRB: Parts Review Board
- MRB: Materials Review Board
- CMRB: Configuration Management Review Board
- SRC: Standing Review Committee

Configuration Control and Management

- Spacecraft Program Office
- Configuration Document Generation
- CIDL
- Configuration Change Control

RELIABILITY PLANNING & MANAGEMENT

Initial Planning

- Reliability Requirements
- System configuration based on heritage
- Participation of Reliability Engineer

Project Management

- Designated Project Executives
- Identification of Critical elements
- Project specific Product Assurance Plan

Review Mechanism

- Immediate discussions on reliability concerns
- Active Participation in NCR management Boards
- Focus on reliability concerns at all hierarchical levels
- Decisions based on judgment and technical merits

Other Factors

- Quality Culture is imbibed in design and manufacturing agencies
- Training and certification of personnel
- Participation of Industries as “Partners”
- Top management

RELIABILITY GROWTH PROCESS
ISRO EXPERIENCE

RELIABILITY GROWTH PROCESS – ISRO EXPERIENCE

- Three phases of Indian Space Programme
- Experimental phase
- Developmental phase
- Operational phase
- Sequence followed in R & QA requirements implementation
  - Generation of guidelines / standards
  - NASA / ESA standards as baseline reference standards
  - Tuning of standards based on our own experience
  - Test facility build-up (functional and environmental)

RELIABILITY GROWTH PROCESS – ISRO EXPERIENCE contd....

- Comprehensive product assurance plan generation
- Standardization across work centers
- Vendor development, qualification and certification
- ISO 9000 certification programme

Accomplishing Reliable Projects – Aiding Factors

- Strong support from Government for the space projects ISRO
- Significant resource Investments
- Matrix management structure
- Establishment of integrated facilities for manufacturing and testing under one roof
- Ample availability of Technical Manpower at affordable cost
- One hundred percent inspection
- Comprehensive testing at various stages

Accomplishing Reliable Projects – Aiding Factors contd…

- Industry participation on selective basis under direct surveillance by ISRO team
- Special committees like Environmental Test Levels Committee (ETLC), thermovac and Dynamic committees
- Apex bodies like Directorate of Quality and Reliability (DOQR) and Product Assurance Board (PAB)
- Involvement of topmost management in Technical reviews
- Independent Review mechanism involving experts from industries, R&D institutions and academia
- National level review committee to review on orbit failures

R & QA Experiences and lessons learnt

- HMC Testing
  - Leakage currents were observed during testing even after successfully passing screening tests.
  - Traced to “dendrite growth” within the HMC package.
  - Caused by interaction of moisture entrapped within the cavity of the package with very minute process residues.
  - A new test called active thermal cycling of HMCs was introduced as a part of screening tests to bring out this problem

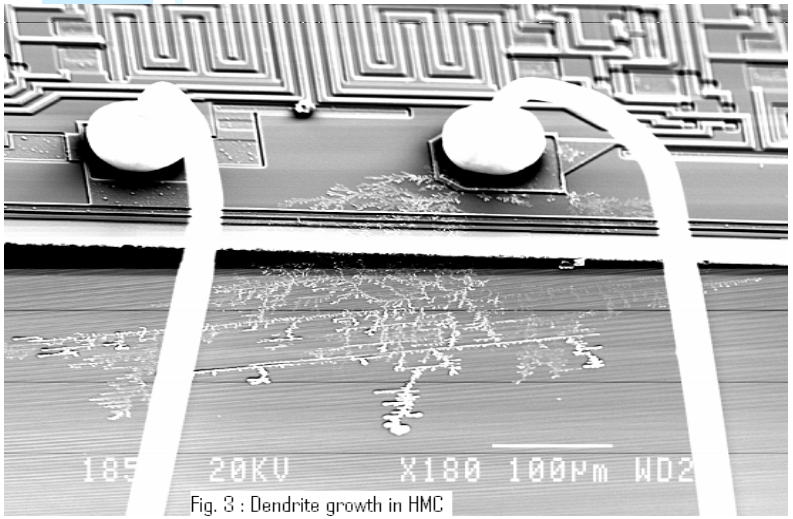


Fig. 3 : Dendrite growth in HMC

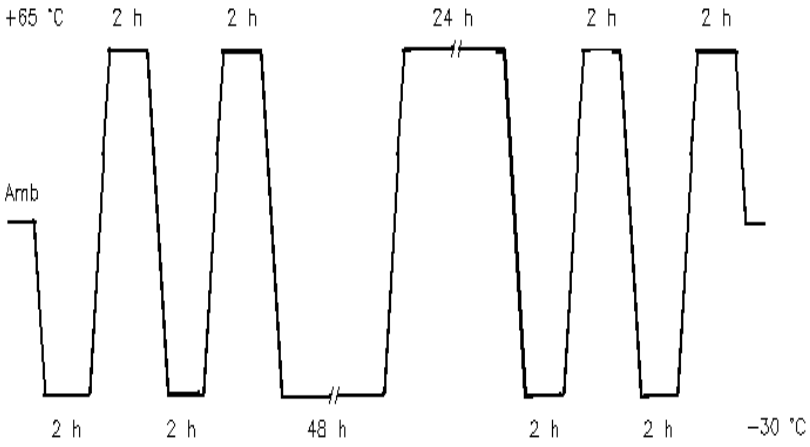
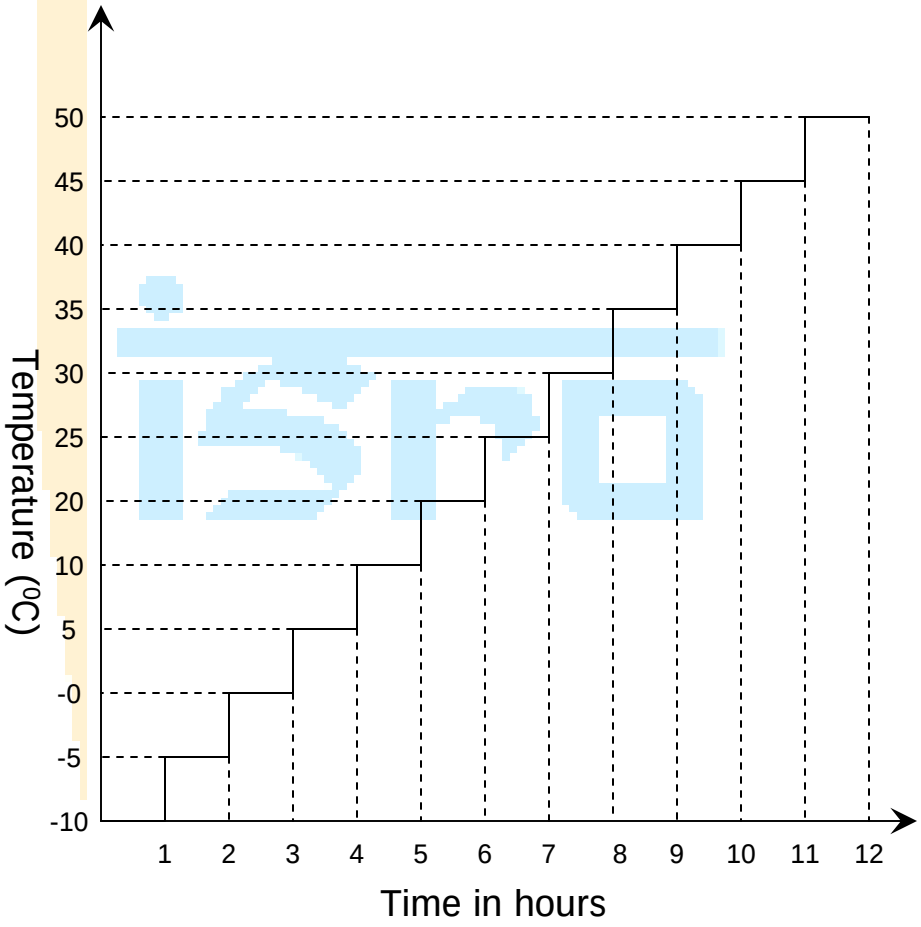


Figure 4 ATC profile

R & QA Experiences and lessons learnt

- RF System Testing
  - Performance of RF systems at spacecraft level tests was not satisfactory at intermediate temperatures
  - Caused by variation of impedance/ gain at intermediate temperatures
  - Correlatable data not available from subsystem tests for similar conditions
  - Introduction of Step test to characterize the subsystem performance at every 5^0C.



R & QA Experiences and lessons learnt

- Thermovac cycling vs thermal cycling tests
  - Effectiveness of thermal cycling over thermo-vacuum cycling was studied.
  - Results indicated that radiation coupled thermovac cycling does not give adequate temperature rate (only 0.1 to 0.3 °C/minute), hence less effective
  - ISRO is contemplating to change over to thermal cycling, where the rate of change could be as high as 5°C/minute.
  - Effectiveness of screening can also be improved by increasing the number of cycles to 8 or 10.

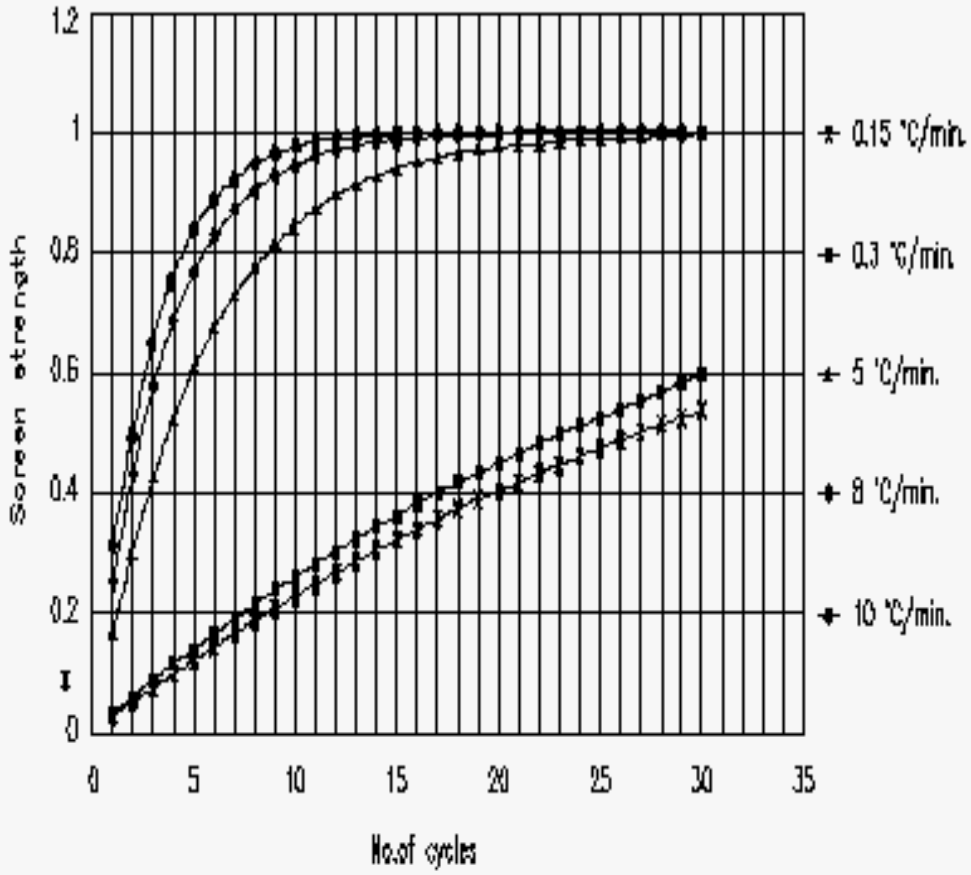


Figure 5 Thermal cycling effectivenss (ΔT = 70 °C)

R & QA Experiences and lessons learnt

- De-rating Criteria for Capacitors
  - Based on the experience of the themo-vacuum testing of converters a 50% de-rating guidelines for ripple current has been introduced.
- Process improvement for semi-rigid cable assembly
  - Process improvement was introduced to include black painted copper fins on the cable to increase the thermal radiating area. This improvement significantly reduced the cable temperature.
- Kapton wire problem analysis
  - Based on analysis of arc tracking phenomenon, Kapton wires were replaced by cross linked ETFE wires for exposed and high current carrying lines.

CONCLUSION

- Quality and Reliability play a major role in all the space programmes from their inception. ISRO is no exception
- R & QA practices at ISRO evolved over time, as its programmes entered operational phase, through experimental and developmental phases
- While adhering to the standard practices/guidelines, R & QA community at ISRO has shown enough flexibility to tailor these, based on our own experience / requirements

CONCLUSION contd….

- The successful implementation of R & QA requirements can be gauged through the success, which ISRO achieved in it's state of the art remote sensing, communication, meteorology and scientific satellites and associated services
- The systems are continuously being monitored, reviewed, modified without sacrificing the ultimate goal of providing reliable services
- In a single sentence

  `Continuous innovation and improvement'

  has been the cardinal principle for us since the inception of our programmes

Thank you

Parts Review Board

- Source Assessment
- Quality Level
- Heritage
- Procurement Specifications
- Standardization type
- Radiation

Material and Process Control Board

- ESD Control
- Particle Induced Noise Detection
- Workmanship standards
- Materials and Process Qualification
- Acceptance testing

Project specific Product Assurance Plan

- New developments
- Qualification requirements
- Critical components / sub assemblies
- Specific areas for focused attention
- Time frame for identification of major areas of thrust for reliability ~ T0+6 months