NASAPLANED DEVELOPMENT PROGRAM
FOR
MICROSPACERCRAFT PRODUCT ASSURANCE

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4/26/95
MICROSPACECRAFT STUDY EFFORT

Why

- Determine existing state of microspacecraft development and status of mission assurance activity

- Identify mission assurance activities which enable acceleration of new technologies or improve schedule/cost

- Identify mission assurance roadblocks which retard progress and remove them or develop improvements
\[ \mu\text{-S/C STUDY -- PROCESS FLOW} \]

**INFORMATION SOURCES**

- SURVEY \(\mu\text{-S/C BUILDERS}\)
- LITERATURE SURVEY
- INTERNAL TECHNOLOGY SURVEY
- OTHER SOURCES OF INFORMATION

**Systemic Issues**
- Screened for \(\mu\text{-S/C Applicability}\)

**Technology List**
- Screened for \(\mu\text{-S/C Applicability}\)

**Map Technologies and Systemic Issues into Relevant Product Assurance Areas**

**List Frequency of Interaction between Relevant PA Areas and Technology/Systemic Issues**

**Recommendations to NASA HQ**

- Observations
- Determinations
- Recommendations

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μ-S/C STUDY DETERMINATION

- Use of new technology is accelerating rapidly
- Product assurance technology assessments/implication should be periodically performed (-2 year centers)
- Technology insertion plan needed to establish degree of preflight assurance validation
- Known good die screening program for high reliability application needed
- Radiation data on commercial and advanced microelectronics needed
- Qualified MMICs and their packaging for telecommunications application is needed
- Manufacturing process critical parameter identification and control need development
- Applications for single build S/C with commercial off-the-shelf hardware needs to be understood
- u-S/C unique QA methodologies need to be identified and developed
- Advanced packaging concepts need development to optimize mass to volume ratio for μ-S/C

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μ-S/C STUDY DETERMINATION (cont.)

● Special light weight materials qualification approaches need clarification

● Approach systematic design assessment for off-the-shelf hardware is needed

● New redundancy strategies for high reliability applications are needed for p-sic

● New standards of reliability practice need to be established

● Long term storage efforts on μ-S/C hardware need to be understood

● Thermal reliability is altered by power and radiating area for μ-S/C. Implications need definition.

● Radiated emissions and susceptibility of μ-S/C are affected by new densities and geometry. Implications need definition.

● Environmental testing needs refocus to p-S/C issues and logistics

● Improved defect detection and prevention methods needed
## RECOMMENDATIONS

<table>
<thead>
<tr>
<th>Product Element</th>
<th>Deliverable</th>
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</thead>
</table>
| **μ-S/C Requirements/Reduction** Thrust | **μ-S/C Product Assurance Guidelines**  
Report on process of reductions and conclusions rationale |
| Risk/Requirements Trade-offs | Guidelines containing μ-S/C risk trade-off depictions |
| Defect Detection/Prevention | ACEQ methodology for application to μ-S/C  
Cost trade-off matrices |
| Technology Insertion Plan/Process | Detailed technology insertion plan identifying technical status and required actions |
| Parts Radiation Data Base | Report on radiation data, recommended design approach, hardness methods |
| MMIC Advanced Telecom Technology | MMIC qualification methodology  
List of advanced MMIC devices qualified  
Qualification data on qualified MMICs |
| Long Life/Long Term Storage | Guidelines for design and test to assure μ-S/C long life/storage adequacy |
| Critical Parameters Ident. and Control | Methodology for utilizing identified critical parameters in manufacturing cycle |
| Guidance & Control Technology Qual. | Qual. methodology for ring laser gyro, micro-machined gyro, interferometric gyro |
| Test Bed Criteria for Minimal Building Hardware | Reporting containing approach for implementing reliability and environmental test concurrent with test bed development activity and criteria for validation status |
| Standard Interface Bus | Reporting containing recommended standard inst./test bed interfaces |
| Characterization of New Structural Materials | List characterizing new technology and materials data for μ-S/C |
\(\mu\)-S/C SUMMARY

- Maximum leverage off of \(\mu\)-S/C study recommendations is obtained by:
  - Application of top 4 recommendations to New Millennium
  - Quick start of these tasks
  - Rapid delivery of products (cumulative)

- Planned activity is collected into a Safety and Mission Assurance (Code Q) thrust for New Millennium

NEW MILLENIUM MISSION ASSURANCE REQUIREMENTS

Additional Title Changes are:

<table>
<thead>
<tr>
<th>Recommended Title</th>
<th>New Name</th>
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<tbody>
<tr>
<td>(\mu)-S/C Requirements Reduction Thrust + New Millennium Requirements Development</td>
<td>No Change</td>
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<tr>
<td>Risk Requirements Tradeoffs</td>
<td>(\rightarrow) No Change</td>
</tr>
<tr>
<td>Defect Detection/Prevention</td>
<td>(\rightarrow) No Change</td>
</tr>
<tr>
<td>Technology Insertion Plan/Process</td>
<td>(\rightarrow) Technology Readiness Assurance Guideline</td>
</tr>
</tbody>
</table>
NEW MILLENNIUM MISSION ASSURANCE REQUIREMENT

PROJECT ADOPTED REQUIREMENTS

- Design
- Qualification
- Manufacture
- Acceptance

NEW MILLENNIUM REQUIREMENTS DEVELOPMENT *

- Relate important requirements to existing requirement set
- Produce a recommended set of New Millennium product assurance requirements for project acceptance

RISK/REQUIREMENTS TRADE-OFFS

- Depict the relationship of parameter variations for each requirement for intelligent risk assessment and value determination
- Produce simple, clear guidelines for relative risk assessment of decisions which deviate from recommended product assurance

DEFECT DETECTION/PREVENTION

- Produce methodology for value based decisions related to failure mechanisms and selected test/test conditions
- Produce cost trade-off matrices

TECHNOLOGY READINESS ASSURANCE GUIDELINE**

- Guideline to establish when technology is sufficiently producible and survivable for infusion into demonstration mission
- Collaborative effort within industry for development of repeatability and qualification criteria

EXISTING ACTIVITIES CONTRIBUTE

- Technical Risk Assessment
- Env. Test Effectiveness Analysis
- Flight Anomaly Characterization
- NASA Preferred Practices

EXISTING ACTIVITIES CONTRIBUTE

- REL TECH Reliability Modeling
- Surface Mount Technology and Process Qualification
- Area Array

* Previously called μ-S/C Requirements Reduction, achieved through either elimination of existing requirements or project tailoring.
** Previously called μ-S/C Technology Insertion Plan.
EXAMPLE OF REQUIREMENTS/VALUE/TRADEOFFS

New Millennium Requirements Development
- Design
- Manufacture
- Test
  - Dynamics
  - EMC
  - Thermal
    - Thermal Cycling
    - Thermal/Vacuum - 75°C @ 144 hr.
    - -200°C @ 24 hr.
- Review

Recommended Mission Assurance Reqsmt

Project Adopted Requirements

Technology Readiness Guidelines

Technology Qualification Guidelines

Alternative Solutions for Decisions

Resource/Capability Description

Risk/Reqmt Tradeoff
Thermal Vac

\[ \lambda_T = A e^{\left[ \frac{E_a}{K} \left( \frac{1}{T} - \frac{1}{T_0} \right) \right]} \]

Parameters of Th-Vac

Defect/Detection/Prevention
Failure Modes (Excited)

AN ALTERNATIVE CAN BE DEVELOPED.
CAVEAT: PHYSICS OF FAILURE THRESHOLD EFFECT CAN BE AFFECTED BY LEVEL.

Test Temp = T_T assume 60°C.
For 60°C to screen as 75°C (Assume \( \frac{\lambda_{75}}{\lambda_{60}} = 2 \))

x Hrs. @ \( \lambda_{75} \) 144 Hrs. = 144 (2) = 288 Hrs. for equivalent stress f(t).
60 deg. C. ( \( \lambda_{60} \) )

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SUMMARY

. New technology and new concepts require new approaches

. Cost and schedule are major considerations, but quality and reliability must be maintained

. Succinct, clear, usable technical relationships must be articulated for understanding of value and content so project managers can make informed mission assurance decisions

. Less mission assurance can be of more value when the success achieved by cost effective and prudent risk taking is greater than the cost of failure