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COMPUTATIONAL CONTROLS FOR AEROSPACE SYSTEMS

JPL

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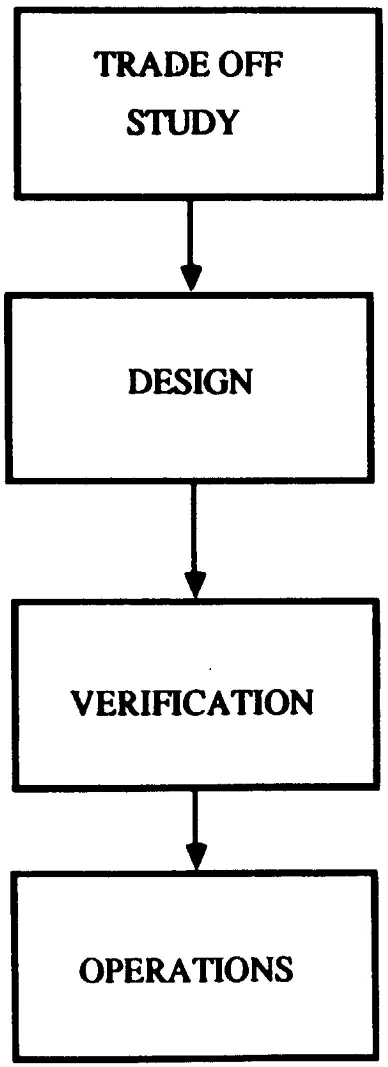
COMPUTATIONAL CONTROLS
OBJECTIVE

DEVELOP THE NEXT GENERATION GUIDANCE AND CONTROL ANALYSIS AND DESIGN TOOLS TO ENABLE FUTURE MISSIONS AND TO IMPROVE PRODUCTIVITY AND RELIABILITY.

TOOLS FOR CONTROL SYSTEM DEVELOPMENT



- SPACECRAFT CONFIGURATION TRADE STUDIES
- CONTROL HARDWARE SELECTION AND PLACEMENT

- PLANT MODELING
- DETAILED DESIGN
- DESIGN ASSESSMENT

- FLIGHT AND GROUND SOFTWARE INTEGRATION
- PERFORMANCE DEMONSTRATION
- HARDWARE IN THE LOOP REAL TIME VERIFICATION

- REAL TIME OPERATIONS
- SYSTEM IDENTIFICATION
- ANOMALY INVESTIGATION

TOOLS ARE INDISPENSIBLE FOR CONTROL SYSTEM DEVELOPMENT

GOALS FOR NASA COMPUTATIONAL CONTROL

- IMPROVE QUICK-DESIGN TURN AROUND TIME BY A FACTOR OF 16 (4 MONTHS → 1 WEEK)
- IMPROVE EVALUATION TURN AROUND TIME BY A FACTOR OF 40 (10 MONTHS→ 1 WEEK)
- ENABLE REAL TIME HARDWARE-IN-THE-LOOP SIMULATION OF COMPLEX SPACECRAFT
- ENABLE REAL TIME ANOMALY INVESTIGATION FOR OPERATIONS
- ENABLE TOOLS TO HANDLE 300 STATES BY 1992 AND 1000 STATES BY 1996

RATIONALE

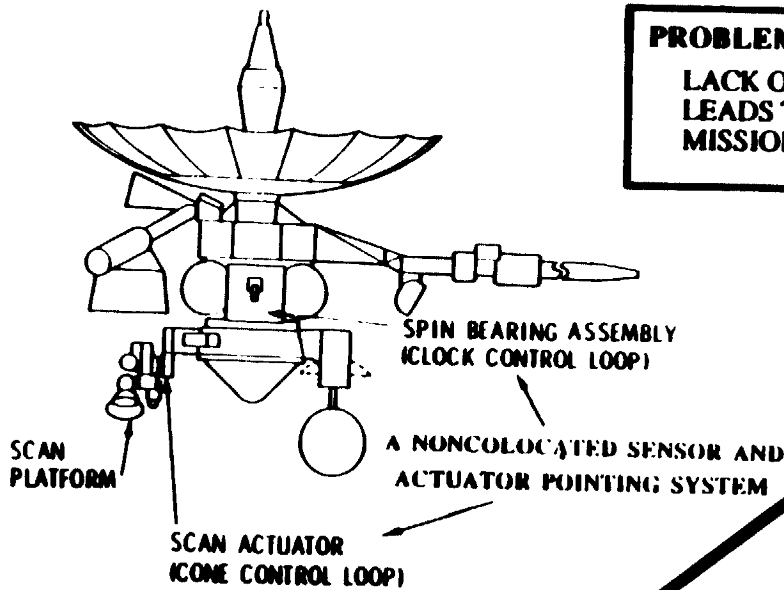
- LACK OF QUICK-DESIGN TOOLS TO IMPACT SPACECRAFT DESIGN
- LACK OF EFFECTIVE EVALUATION TOOLS TO CHECK DESIGN MARGIN & PERFORMANCE
- LACK OF REAL TIME SIMULATION TOOL OF REALISTIC SPACECRAFT TO CERTIFY DESIGN
- LACK OF QUICK DIAGNOSTIC TOOLS FOR MISSION OPERATIONS

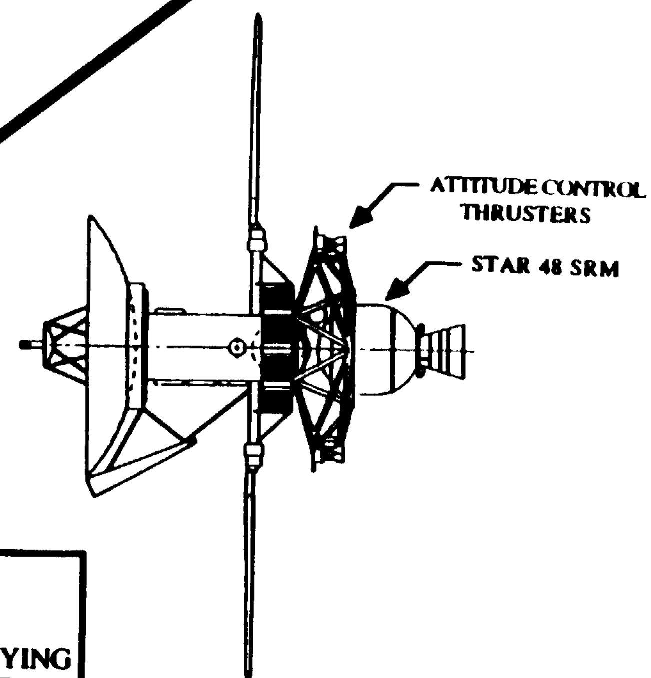
LACK OF PROPER TOOL CREATES INTOLERABLE RISK FOR FUTURE SPACECRAFT SYSTEMS

THE GALILEO CONTROL DESIGN PROBLEM

PROBLEM:

LACK OF QUICK-LOOK TOOL LEADS TO FAILURE TO MEET MISSION REQUIREMENTS



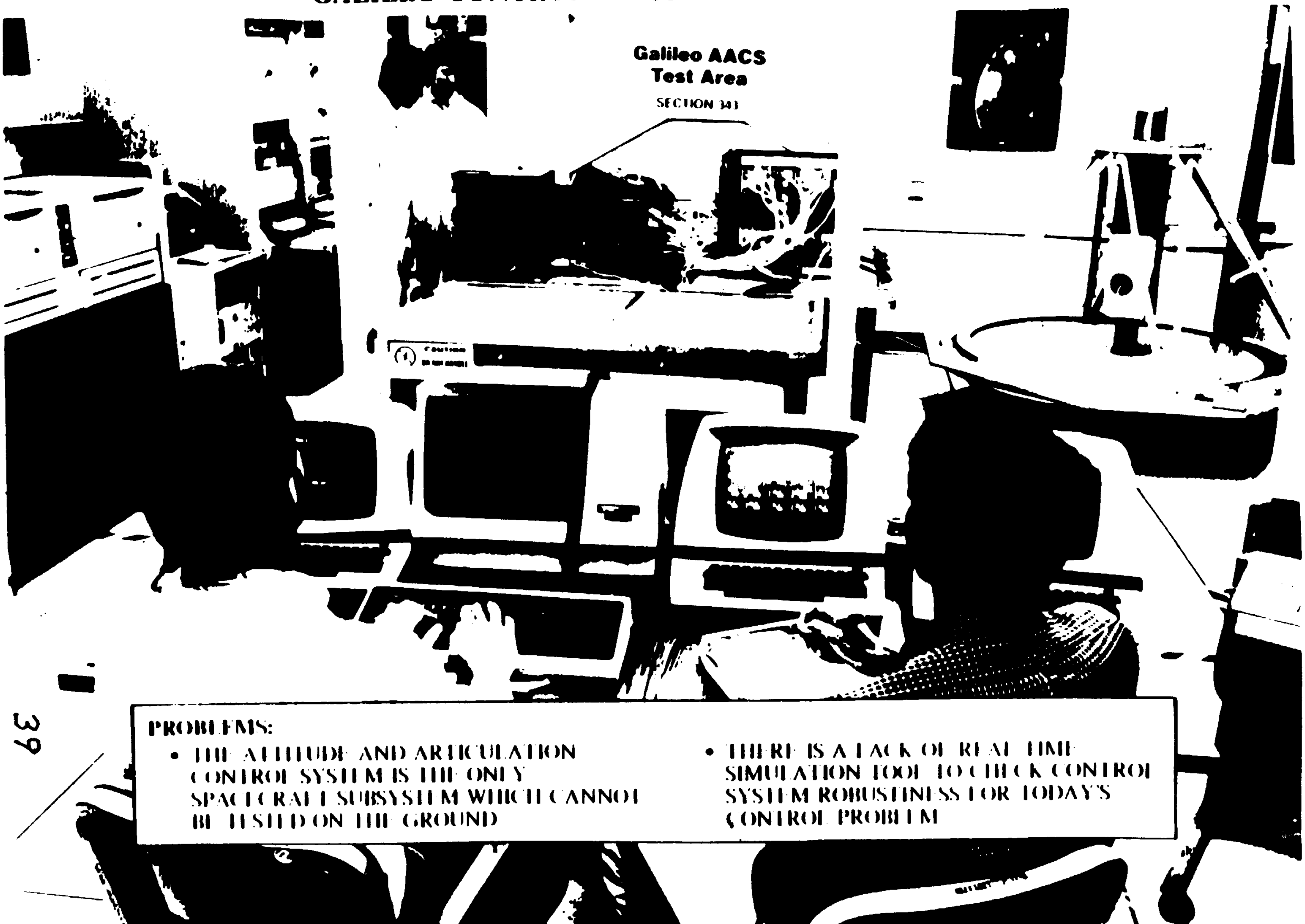


PROBLEM:

LACK OF EFFECTIVE EVALUATION TOOL PROHIBITS US FROM IDENTIFYING A MISSION CATASTROPHIC FAILURE DURING VENUS ORBIT INSERTION

MAGELLAN SPACECRAFT VENUS ORBIT INSERTION PROBLEM

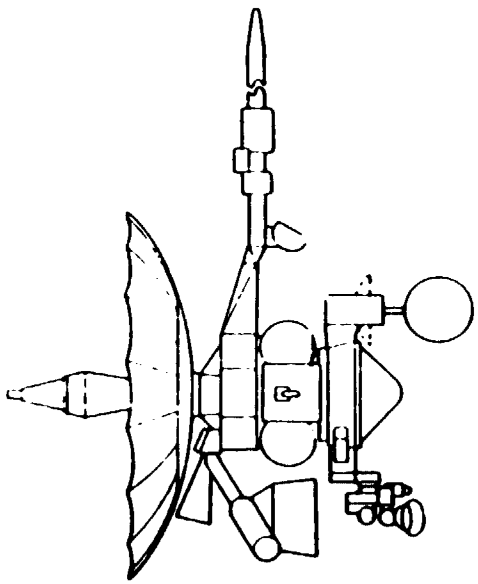
GALILEO CONTROL SYSTEM REAL TIME TESTING

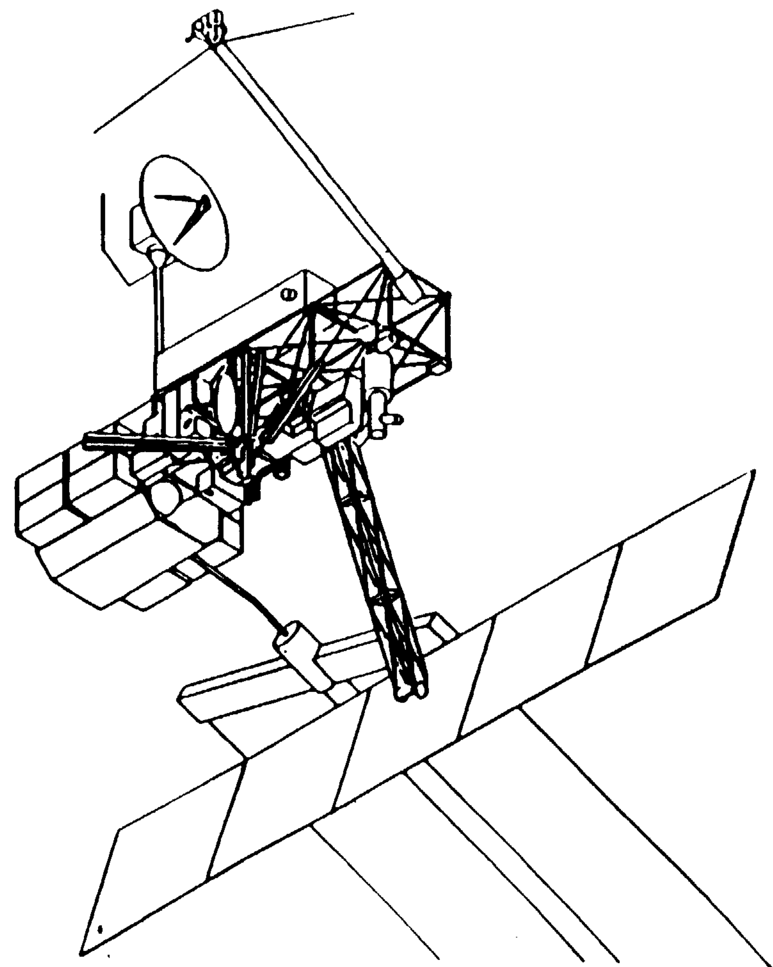


PROBLEMS:

- THE ATTITUDE AND ARTICULATION CONTROL SYSTEM IS THE ONLY SPACECRAFT SUBSYSTEM WHICH CANNOT BE TESTED ON THE GROUND
- THERE IS A LACK OF REAL TIME SIMULATION TOOL TO CHECK CONTROL SYSTEM ROBUSTNESS FOR TODAY'S CONTROL PROBLEM

MISSION OPERATIONS SUPPORT IS INADEQUATE

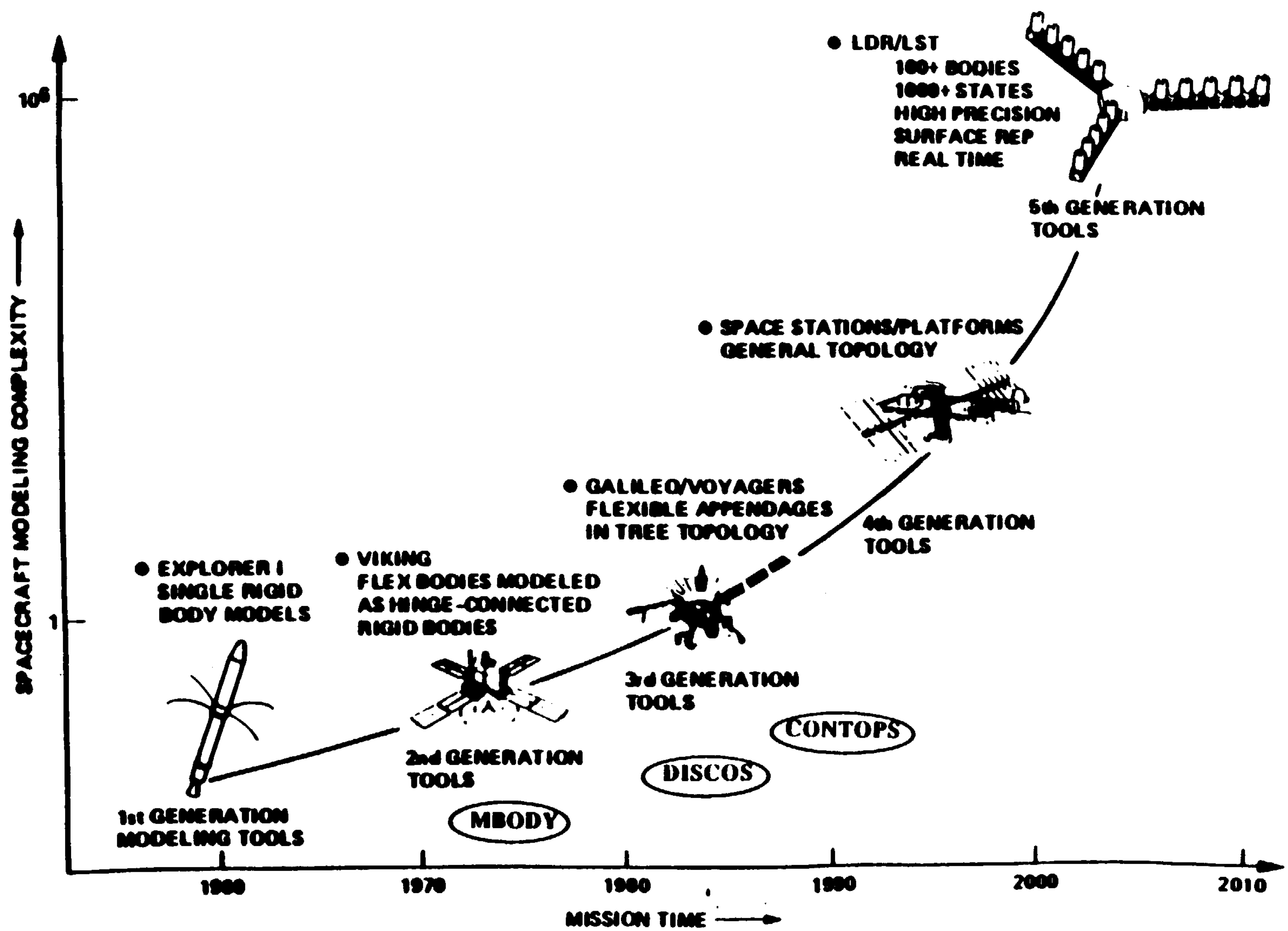




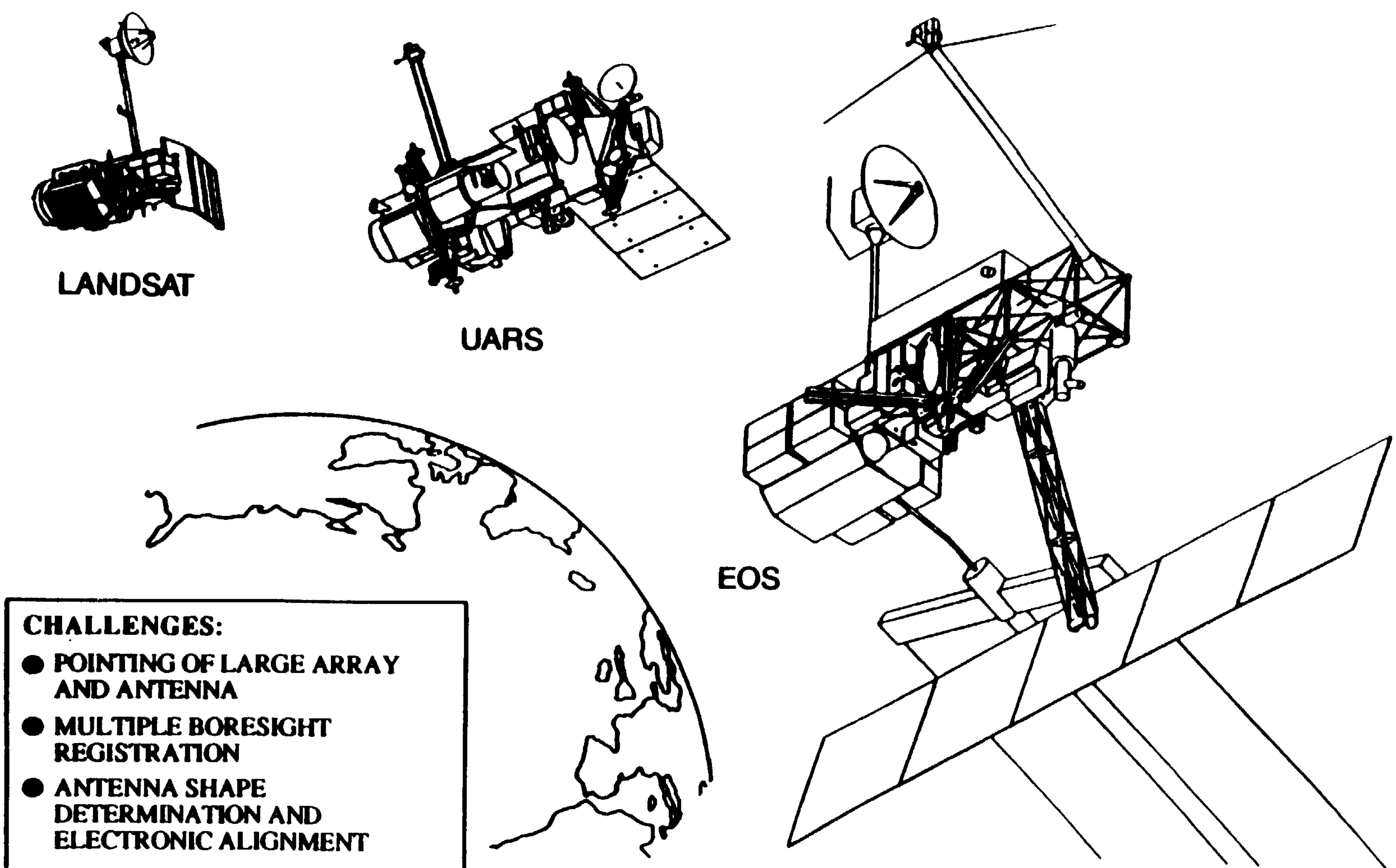
PROBLEM:

LACK OF QUICK DIAGNOSTIC TOOL FOR ANOMALY INVESTIGATION LEAD TO CONCERNS IN TURN AROUND TIME FOR OPERATIONS

GROWTH IN SPACECRAFT MODELING COMPLEXITY

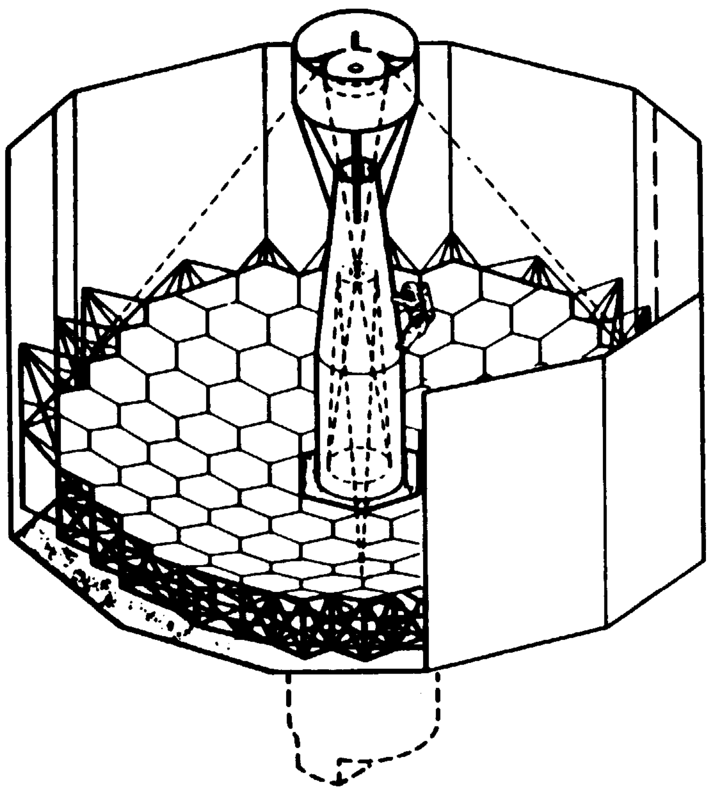


EVOLUTION OF EARTH OBSERVING PLATFORMS



CHALLENGES:
- POINTING OF LARGE ARRAY AND ANTENNA
- MULTIPLE BORESIGHT REGISTRATION
- ANTENNA SHAPE DETERMINATION AND ELECTRONIC ALIGNMENT

ADVANCED ASTROPHYSICAL INSTRUMENTS



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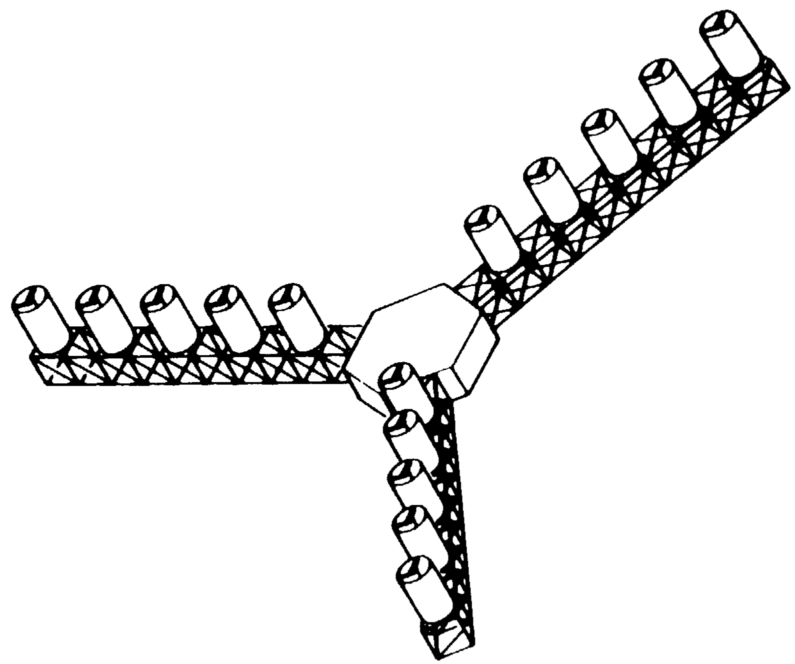
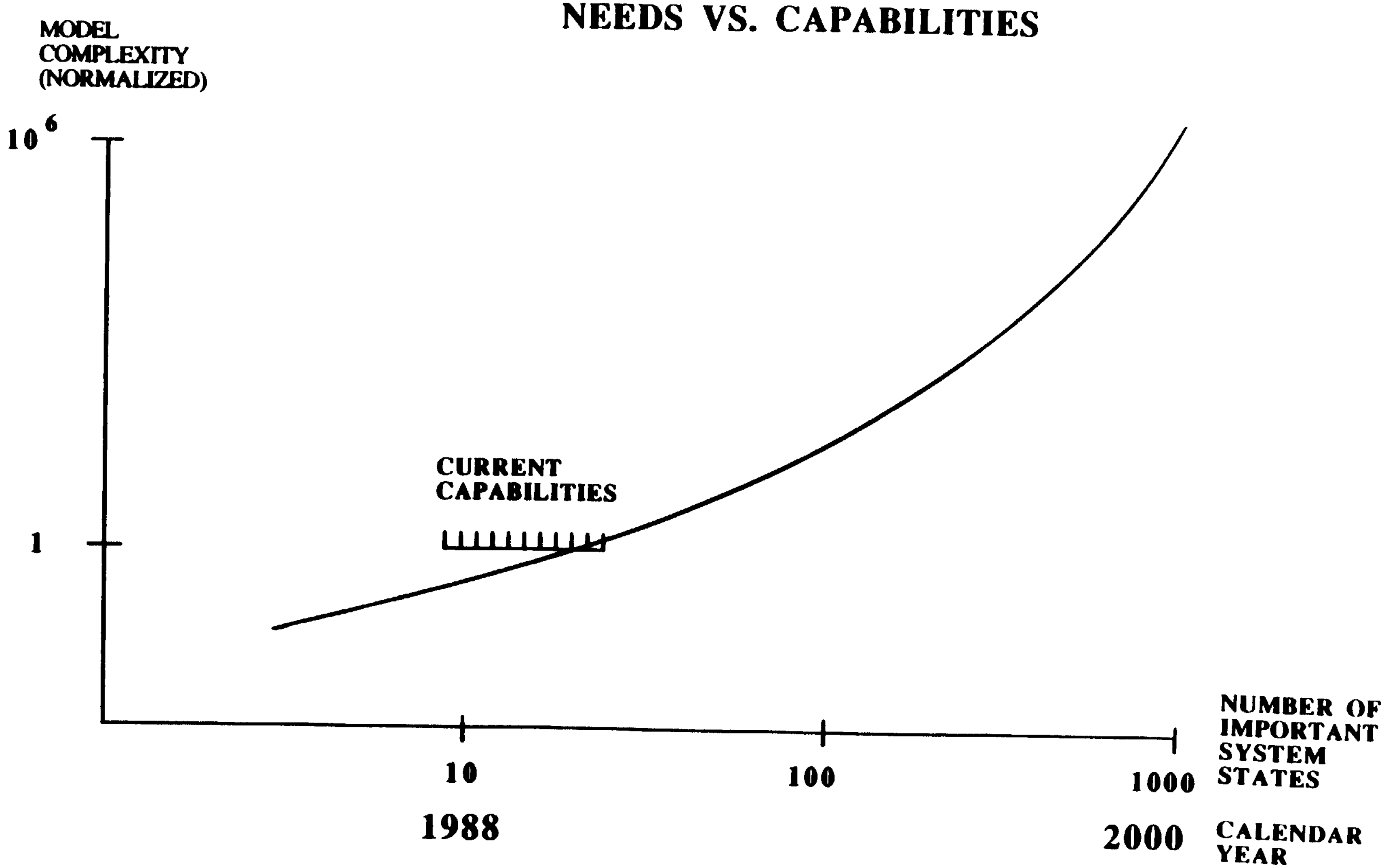


ASTROPHYSICAL INTERFEROMETER

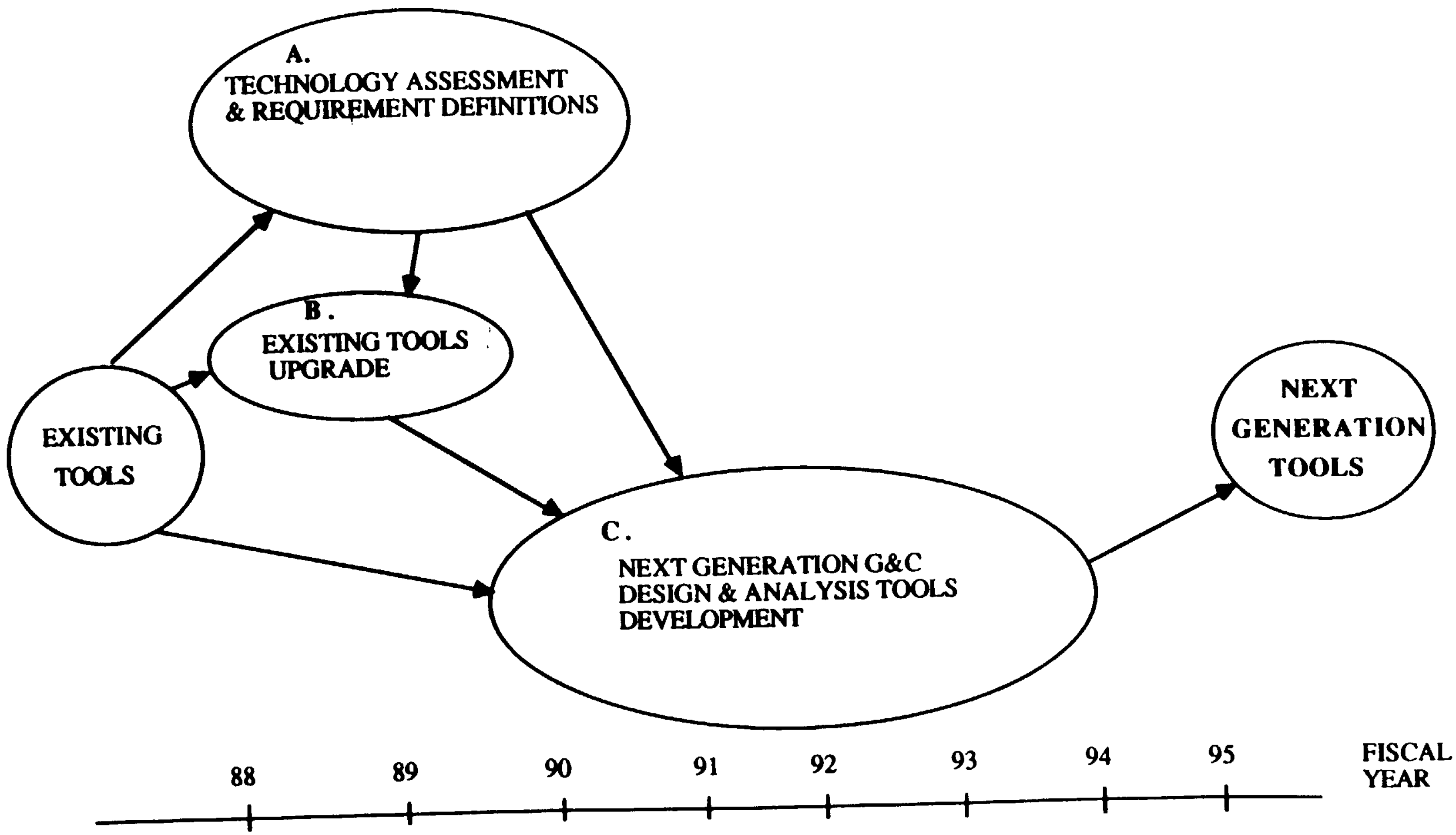
CHALLENGES:
- SHAPE DETERMINATION AND ACTIVE CONTROL
- SUBWAVELENGTH PHASING OF OPTICAL PATHS
- DISTRIBUTED SENSING AND ACTUATION

CONTROL DESIGN AND ANALYSIS NEEDS VS. CAPABILITIES



EXISTING TOOLS ARE A LIMITING FACTOR IN TODAY'S CONTROL DESIGN AND VERIFICATION, AND ARE INADEQUATE FOR FUTURE NEEDS

COMPUTATIONAL CONTROLS APPPROACH



COMPUTATIONAL CONTROLS APPROACH CONT.

A. TECHNOLOGY ASSESSMENT & REQUIREMENT DEFINITIONS

- MULTIBODY SIMULATION TECHNOLOGY VERIFICATION
- CONTROL SYSTEM DESIGN/ANALYSIS TOOL ASSESSMENT
- REQUIREMENT DEFINITION AND ANALYSIS

B. EXISTING TOOLS UPGRADE

- UPDATE TOOLS WITH KNOWN DEFICENCIES
- UPGRADE TOOLS TO MEET NEAR TERM NEEDS

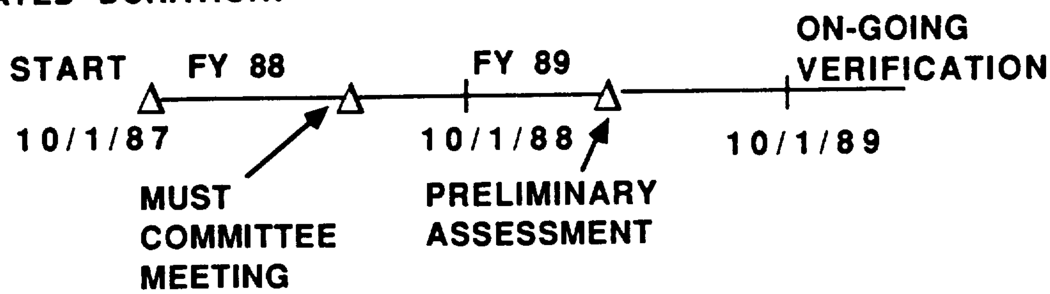
C. NEXT GENERATION TOOLS DEVELOPMENTS

- MULTIBODY SIMULATION TOOLS
- CONTROL SYSTEM OPTIMIZATION
- TOOLS FOR MODERN COMPUTING ENVIRONMENT
- ACCURATE SURFACE MODELING & REPRESENTATION TOOLS
- INTEGRATED CONTROL DESIGN ENVIRONMENT

MULTIBODY SIMULATION ASSESSMENT & VERIFICATION PLAN

PLAN SUMMARY:

- ESTIMATED DURATION:



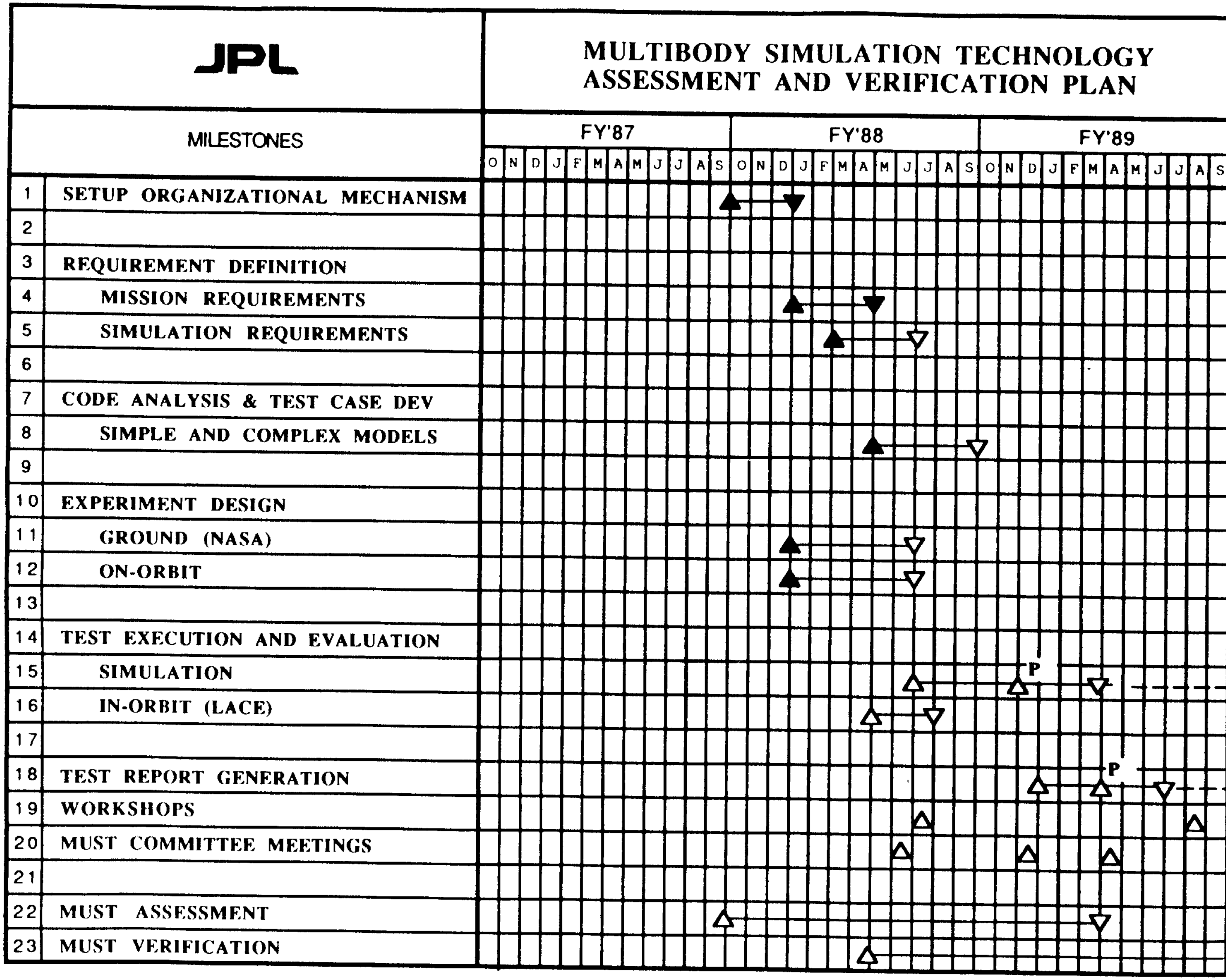
SCHEDULE:

1ST YEAR
- REQUIREMENT DEFINITION AND ANALYSIS
- ESTABLISH VERIFICATION LIBRARY
- TEST CASE DEVELOPMENT

2ND YEAR
- TEST CASE EXECUTION AND EVALUATION
- EXPERIMENT EXECUTION AND EVALUATION
- TEST REPORT GENERATION

FUTURE YEARS:
- CONTINUE TO BUILD VERIFICATION LIBRARY
- VERIFY NEW TOOLS AS THEY ARE DEVELOPED

DELIVERABLES:
- QUESTIONNAIRES
- REQUIREMENTS MATRIX
- TEST PLAN
- TEST CASE REPORT
- FINAL REPORT
- TWO WORKSHOPS
    - COMPUTATIONAL ASPECTS OF FLEXIBLE BODY SYSTEMS
    - FINAL REPORT TO THE COMMUNITY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MULTIBODY SIMULATION TECHNOLOGY ASSESSMENT AND VERIFICATION PLAN
MILESTONES
FY'87
FY'88
FY'89
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1 SETUP ORGANIZATIONAL MECHANISM
2
3 REQUIREMENT DEFINITION
4 MISSION REQUIREMENTS
5 SIMULATION REQUIREMENTS
6
7 CODE ANALYSIS & TEST CASE DEV
8 SIMPLE AND COMPLEX MODELS
9
10 EXPERIMENT DESIGN
11 GROUND (NASA)
12 ON-ORBIT
13
14 TEST EXECUTION AND EVALUATION
15 SIMULATION
16 IN-ORBIT (LACE)
17
18 TEST REPORT GENERATION
19 WORKSHOPS
20 MUST COMMITTEE MEETINGS
21
22 MUST ASSESSMENT
23 MUST VERIFICATION
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