NASA-CR-191312

HL14-1333

p. 146

# DETAILED TECHNICAL REPORT

## VOLUME III

# SHUTTLE LAUNCH SITE OPERATIONAL CONCEPTS FOR CERTAIN SORTIE MISSIONS

23 MARCH 1973

Prepared under:
Contract NAS 10-8043


TRW
SYSTEMS GROUP OF TRW INC
FLORIDA OPERATIONS · 7001 NORTH ATLANTIC AVENUE CAPE CANAVERAL, FLORIDA



LIBRARY
CENTER
CALIF



(NASA-CR-191312) SHUTTLE LAUNCH SITE OPERATIONAL CONCEPTS FOR CERTAIN SORTIE MISSIONS. VOLUME 3: DETAILED TECHNICAL REPORT (TRW Systems Group) 146 p

N93-70548

Unclas

Z9/15 0132852

22414.000

# DETAILED TECHNICAL REPORT
## VOLUME III

# SHUTTLE LAUNCH SITE OPERATIONAL CONCEPTS FOR CERTAIN SORTIE MISSIONS

NAS 10-8043

23 MARCH 1973

Prepared for
National Aeronautics and Space Administration
John F. Kennedy Space Center
Kennedy Space Center, Florida


V. A. DULOCK, JR.
Study Manager
TRW Systems Group

R. L. Norman
NASA Technical Monitor
Kennedy Space Center

# FOREWORD

This document is submitted in accordance with the requirements stated in Section 7.0 of the Statement of Work for KSC Contract NAS 10-8043. In addition, by agreement with the NASA/KSC Technical Monitor, this report satisfies the eighth and final monthly progress report requirement since it presents the study results for the last three months.

## DISCUSSION TOPICS

This volume reports on all or part of the following tasks defined for Phase 3:

- Task 7 - Determine Sensitivity to Perturbations in Mission Density
- Task 8 - Develop Programmatic Plans, Methods, and Procedures
- Task 9 - Define Launch Site Documentation (User's Guide)
- Task 11 - Assess Impact on Launch Site
- Task 12 - Prepare Program Planning Schedule
- Task 13 - Perform Site Trade Study.

Also included in this report are clarifications and answers to questions raised at the Phase 2 presentation.

TABLE OF CONTENTS


| Section | | Page |
|---|---|---|
| 1.0 | INTRODUCTION | 1-1 |
| 2.0 | ACTION ITEMS FROM PHASE 2 REVIEW | 2-1 |
| 3.0 | QR USER'S GUIDE | 3-1 |
| 4.0 | LAUNCH SITE IMPACT | 4-1 |
| 5.0 | QR ORGANIZATION | 5-1 |
| 6.0 | PLANNING SCHEDULES | 6-1 |
| 7.0 | SENSITIVITY TO MISSION DENSITY | 7-1 |
| 8.0 | QR LOCATION ALTERNATIVES | 8-1 |
| 9.0 | SUMMARY | 9-1 |

# 1.0 INTRODUCTION

## STUDY OBJECTIVES

The basic study premise is a Quick-Reaction Sortie Mission; i.e., a user oriented operational concept to afford a window into space for a wide spectrum of users.

The overall study objectives are:

- Define the launch site operational/systems philosophies and hardware/software requirements for a selected set of experiments which lend themselves to a minimum integration, low cost, customer responsive, Quick-Reaction operation.

- Perform a trade study to determine the time/cost perturbations introduced by accomplishing these activities at locations other than the launch site.

# SHUTTLE LAUNCH SITE OPERATIONAL CONCEPTS FOR CERTAIN SORTIE MISSIONS

## STUDY OBJECTIVES

1. TO DEVELOP OPERATIONAL CONCEPTS AND PLANS FOR "QUICK-REACTION" EXPERIMENT INTEGRATION AT THE SHUTTLE LAUNCH SITE.

2. TO DETERMINE THE TIME/COST IMPACT OF PERFORMING ALL OR PART OF THESE ACTIVITIES ELSEWHERE.

TRW

## STUDY GROUND RULES

These ground rules have been established to provide a basis for concept development. The Sortie Lab has been designated as the experiment carrier, and both it and the Shuttle will have completed the development phase in the time frame under consideration. Ownership of the Sortie Lab by the Shuttle Operator has been established as a ground rule for development of the baseline concept only. The last ground rule was adopted at the beginning of Phase 3.

## STUDY GROUND RULES

1. THE SORTIE LAB WILL BE THE QR EXPERIMENT CARRIER.
2. BOTH THE SORTIE LAB AND SHUTTLE WILL BE OPERATIONAL.
3. THE SORTIE LABS ASSIGNED TO QR MISSIONS WILL BE OWNED BY THE SHUTTLE OPERATOR.
4. LIMITED TO MISSIONS NOT INVOLVING PERMANENT CHANGES TO THE SORTIE LAB.

TRW

## OVERALL STUDY ACTIVITIES

The facing page shows the three phases of this study. The Phase 1 results were presented on 17 October 1972 and are documented in Volume I of the Detailed Technical Report. The Phase 1 effort provided the groundwork for developing the Quick-Reaction concept.

The Phase 2 results were presented on 12 December 1972 and are documented in Volume II of the Detailed Technical Report.

This report presents the results of Phase 3. The primary objectives of Phase 3 were to:

- Assess the impact of the implementation of the QR concept on the launch site.
- Assess the impact of location/responsibility alternatives on the QR concept.

# OVERALL STUDY ACTIVITIES

## PHASE 1

ANALYSIS

DETERMINE LAUNCH SITE REQUIREMENTS AND INTERFACES

- CATEGORIZED EXPERIMENT HARDWARE
- REVIEWED OTHER PROGRAMS
- IDENTIFIED GROUND OPERATIONAL REQUIREMENTS
- PERFORMED INTERFACE ASSESSMENT

## PHASE 2

OPERATIONAL CONCEPTS

DEVELOP QUICK-REACTION SORTIE MODE OPERATIONAL CONCEPT

- DEVELOP QRI CONCEPT
  - HARDWARE INTEGRATION
  - SOFTWARE INTEGRATION
  - MISSION INTEGRATION
- WORK BREAKDOWN, ROLES, RELATIONSHIPS
- PROGRAMMATIC IMPACT

## PHASE 3

REQUIREMENTS AND SCHEDULES

- ASSESS LAUNCH SITE IMPACT
- PERFORM SITE TRADE STUDY

- LAUNCH SITE INPACT
- SENSITIVITY TO MISSION DENSITY
- QR USER'S GUIDE
- PROGRAM PLANNING SCHEDULE
- LOCATION ALTERNATIVES

TRW

# 2.0 ACTION ITEMS FROM PHASE 2 REVIEW

## ACTION ITEMS FROM PHASE 2

Discussions by the NASA Steering Committee of the Quick-Reaction concept, presented in Phase 2 of this study, resulted in the action items listed on the facing page. In general, the action items are for the clarification of some aspects of software and mission integration.

The baseline set of experiment hardware was to be analyzed for software and mission integration requirements. In addition, two simple experiments were to be exercised through the integration cycle to demonstrate the integration requirements. One of these is the AEROPOL experiment which was described in Phase 2 in a modified version utilizing the Sortie Lab data management system. For this action item, the autonomous version of the AEROPOL (using its own mini-computer) was to be used. Other action items include the clarification of the role of the user throughout the mission cycle and to perform a limited survey of potential users to obtain a broader base of opinion. In addition, an alternate hardware/software integration approach was to be developed, assuming that a flight-qualified Payload Specialist Station (PSS) could be made available for pre-installation testing with the integrated Sortie Lab.

## ACTION ITEMS FROM PHASE II

- ANALYZE BASELINE EXPERIMENTS FOR SOFTWARE AND MISSION INTEGRATION REQUIREMENTS
- SHOW INTEGRATION OPERATIONS FOR AUTONOMOUS AEROPOL EXPERIMENT
- SHOW INTEGRATION OPERATIONS FOR SIMPLE EXPERIMENT
- CLARIFY USER'S ROLE IN INTEGRATION OPERATIONS
- OBTAIN BROADER BASE OF USER OPINION
- INVESTIGATE INTEGRATION CONCEPT USING SPARE FLIGHT QUALIFIED PSS

TRW SYSTEMS GROUP

## EXPERIMENT HARDWARE GROUPS

The experiments listed on the facing page are the baseline Quick-Reaction experiments presented in Phase 1 of this study. They were taken from Appendix A of the Statement of Work, Green Book, Skylab Program Operational Data Book and other documentation. The experiments are shown in groups per integration and facilities requirements; i.e., Group A experiments are optical types using cameras for data retrieval; Group B are optical types only; Group C are electric field sensors; Group D are RF sensors; Group E are ambient environment sensors and Group F are biological experiments.

# EXPERIMENT HARDWARE GROUPS

## GROUP A

SMALL UV TELESCOPE
IMAGE ISOCON TV
UV AIRGLOW HORIZON PHOTOGRAPHY
UV X-RAY SOLAR PHOTOGRAPHY

## GROUP B

MULTISPECTRAL RADIOMETER
SURFACE MOISTURE PHOTOPOLARIMETER
OPTICAL METEOROID DETECTOR
PHOTOMETRIC CLUSTER
MULTISPECTRAL SCANNER

## GROUP C

ELECTROSTATIC PROBE
ELECTRIC FIELD PROBE
FLUX GATE MAGNETOMETER

## GROUP D

MICROWAVE SCANNER
L-BAND RADIOMETER
MICROWAVE RADIOMETER

## GROUP E

PLASTIC/NUCLEAR EMULSION
IN-FLIGHT AEROSOL ANALYSIS
DOSIMETERS (PASSIVE & ACTIVE)
THERMAL COATINGS
MASS SPECTROMETER
ION TRAP

## GROUP F

CIRCADIAN RHYTHM
EFFECT OF ZERO G ON SINGLE
HUMAN CELL

TRW

## QR SYSTEM REQUIREMENTS

This chart depicts an overview of the elements comprising Quick-Reaction integration: hardware integration and test, software integration, and mission integration. The requirements shown under each element define the basic job to be done in that area. All requirements must be met in a manner that is quick, low cost, and simple.

# QR SYSTEM REQUIREMENTS

## HARDWARE INTEGRATION & TEST

- LOCATION & INTERCONNECTION IN SORTIE LAB
- VERIFY PERFORMANCE, SAFETY, COMPATIBILITY
- ASSURE COMPATIBILITY WITH GROUND EQUIPMENT & OPERATIONS

## SOFTWARE INTEGRATION

- MEET PI'S NEEDS FOR EXPERIMENT:

  COMMAND
  CONTROL
  DISPLAY
  DATA PROCESSING
  RECORDING

- ASSURE COMPATIBILITY WITH:

  SORTIE LAB DATA MANAGEMENT SYSTEM
  SHUTTLE DATA MANAGEMENT SYSTEM
  GROUND SUPPORT SYSTEMS AND OPERATIONS

## MISSION INTEGRATION

- MEET PI'S FLIGHT OPERATIONAL REQUIREMENTS
- ASSURE COMPATIBILITY WITH SHUTTLE:

  MISSION PLANNING
  MISSION OPERATIONS
  MISSION CONTROL
  FLIGHT CREW OPERATIONS

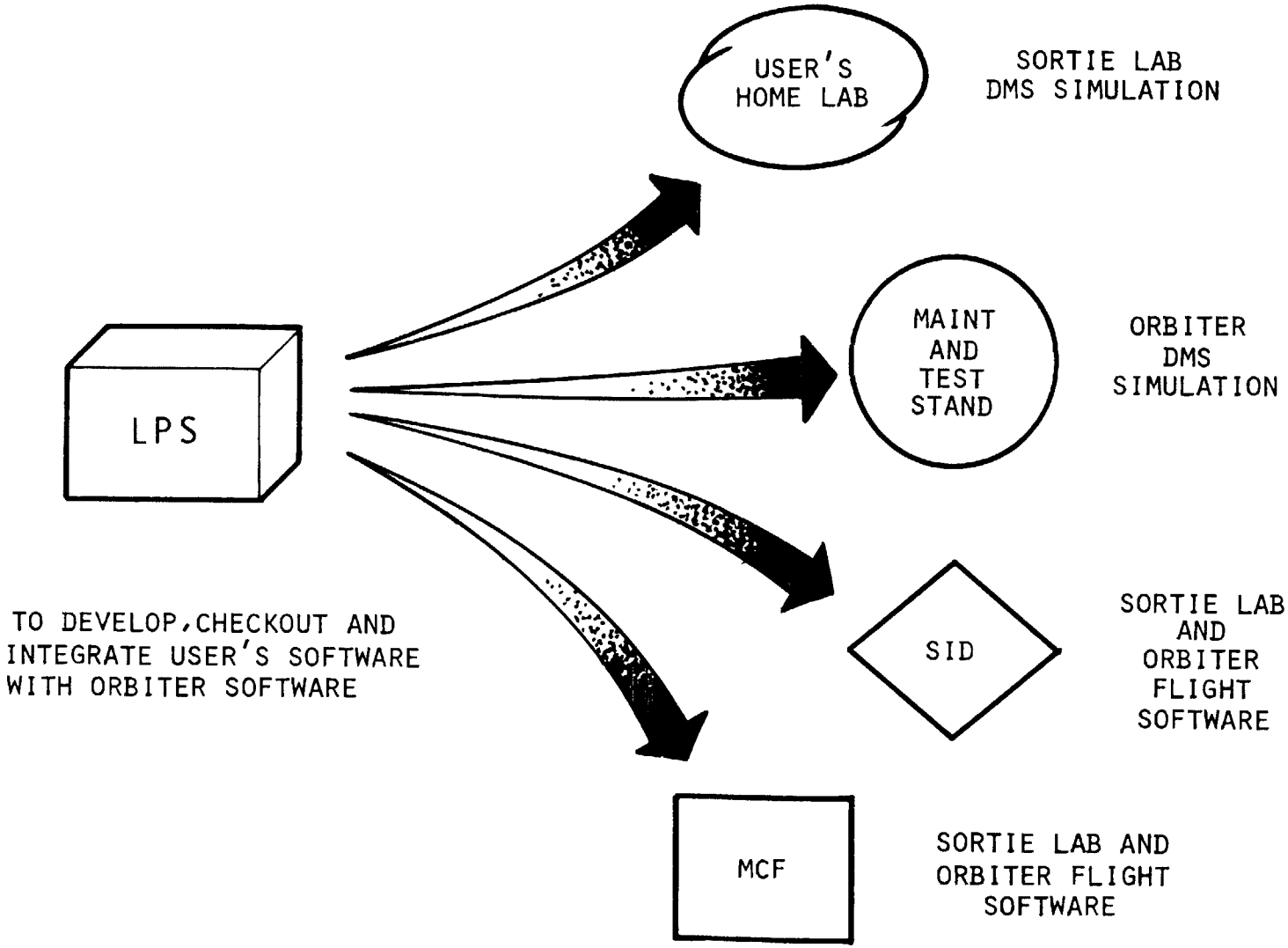
QUICK RESPONSE
LOW COST
SIMPLE

TRW

## SOFTWARE INTEGRATION CONCEPT

A simplified diagram illustrating the software integration concept for those QR experiments with software requirements is presented on the facing page. Four principal locations are shown. In his home lab, the PI develops his experiment software, and its compatibility with the Sortie Lab Data Management System (DMS) is achieved through the use of a DMS simulation. In the Maintenance and Test Stand, the experiment and Sortie Lab flight software are integrated, using a simulation of the Orbiter DMS. The Shuttle Integration Device allows final integration of experiment, Sortie Lab, and Orbiter flight software, so that no unforeseen software problems should occur in the Avionics Operational Test (AOT) in the Maintenance and Checkout Facility (MCF). These functions are accomplished using the proposed Launch Processing System (LPS).

# SOFTWARE INTEGRATION CONCEPT




TO DEVELOP, CHECKOUT AND INTEGRATE USER'S SOFTWARE WITH ORBITER SOFTWARE

TRW

## WHAT ARE SOFTWARE REQUIREMENTS?

The requirements for the generation of software and, hence, the task of integrating the software with the total payload is brought about by user's needs as shown on the facing page. Only when these needs are imposed upon the Sortie Lab Data Management System is there a requirement for software integration.

## WHAT ARE SOFTWARE REQUIREMENTS?

USER NEEDS DATA PROCESSING FOR

- DOWNLINK
- ON-BOARD CONTROL AND DISPLAY
- MAG TAPE RECORDING

TRW

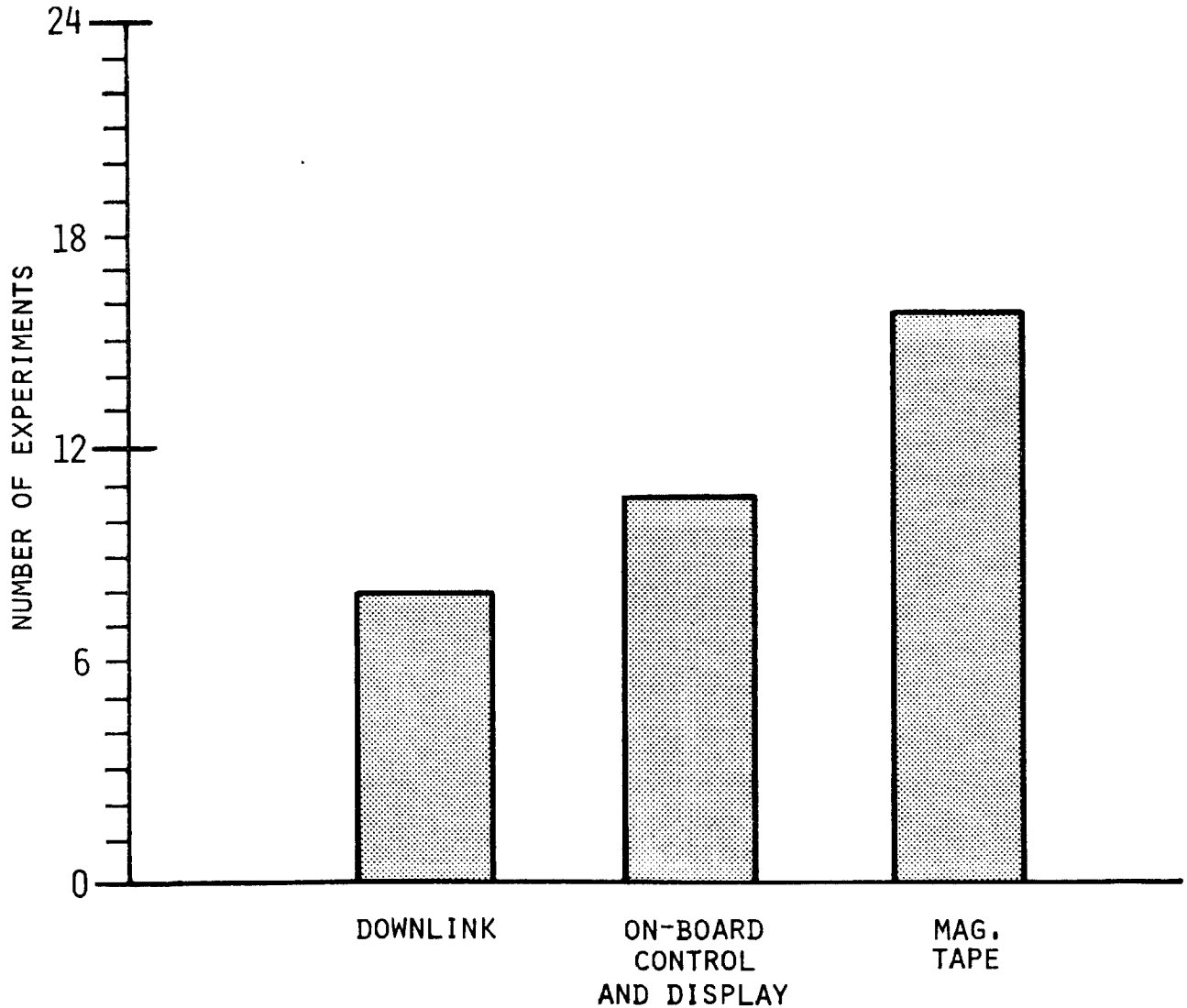
## SOFTWARE INTEGRATION ANALYSIS

Analysis of the 24 baseline experiments was performed to determine if a real requirement exists for software integration. The experiments were screened for downlink, on-board control and display and magnetic tape recording requirements.

The results are shown on the facing page. Eight experiments require downlink, 11 require on-board control and display, and 16 require recording of raw data onto magnetic tape.

# SOFTWARE INTEGRATION ANALYSIS

ANALYSIS OF 24 CANDIDATE EXPERIMENTS

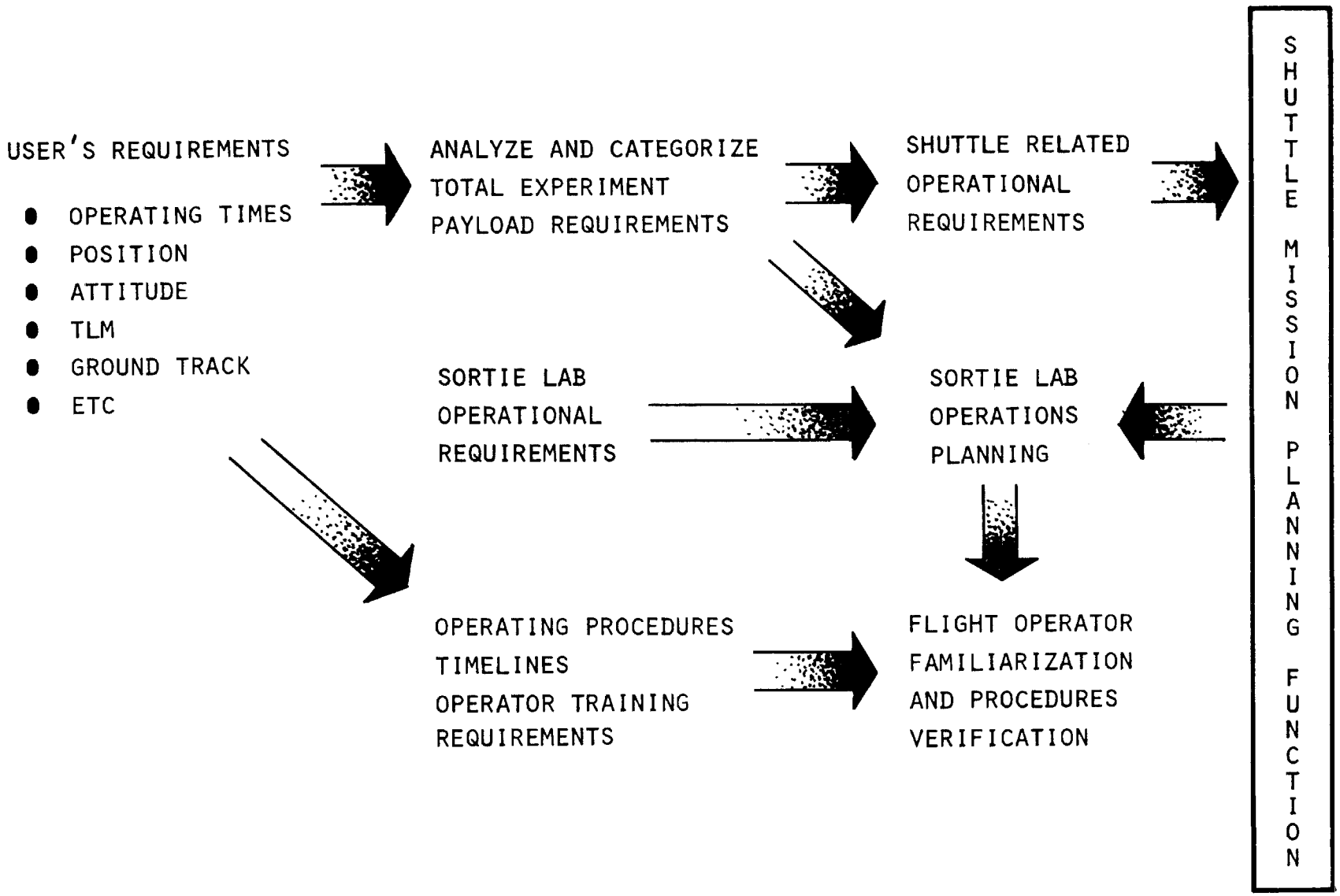



TRW

## MISSION INTEGRATION CONCEPT

The mission integration concept proposed for QR missions is presented. The PI develops his detailed experiment flight operational requirements and submits these on the Experiment Requirements Transmittal (ERT) sheets to the QR Integration activity. Those requirements affecting Shuttle flight operations are transmitted to the Shuttle Mission Planning function, which performs detailed flight planning, trajectory design, and related functions. Those experiment flight operational requirements relating exclusively to internal Sortie Lab and experiment operations are handled by the QRI activity. Detailed flight operating procedures and timelines are developed for the experiments, in consonance with the Shuttle trajectory and timelines, and in close coordination with the PI's. The experiment flight operators verify these procedures in the Shuttle Integration Device (SID).

# MISSION INTEGRATION CONCEPT




TRW

## WHAT ARE EXPERIMENT FLIGHT OPERATIONAL REQUIREMENTS?

Experiment flight operational requirements are those user's needs for Orbiter maneuvering to provide specific attitudes or pointing angles, for stability and control to maintain pointing angles within certain limits and for knowledge of position or ground track for target identification.

The sum total of these requirements for a Sortie mission (i.e., integrated experiment payload flight operations requirements) must be coordinated with the Shuttle Mission Planning function.

## WHAT ARE EXPERIMENT FLIGHT OPERATIONAL REQUIREMENTS?

USER'S NEED FOR:

- KNOWLEDGE OF POSITION
- ORBITER MANEUVERING
- STABILITY AND CONTROL

TRW

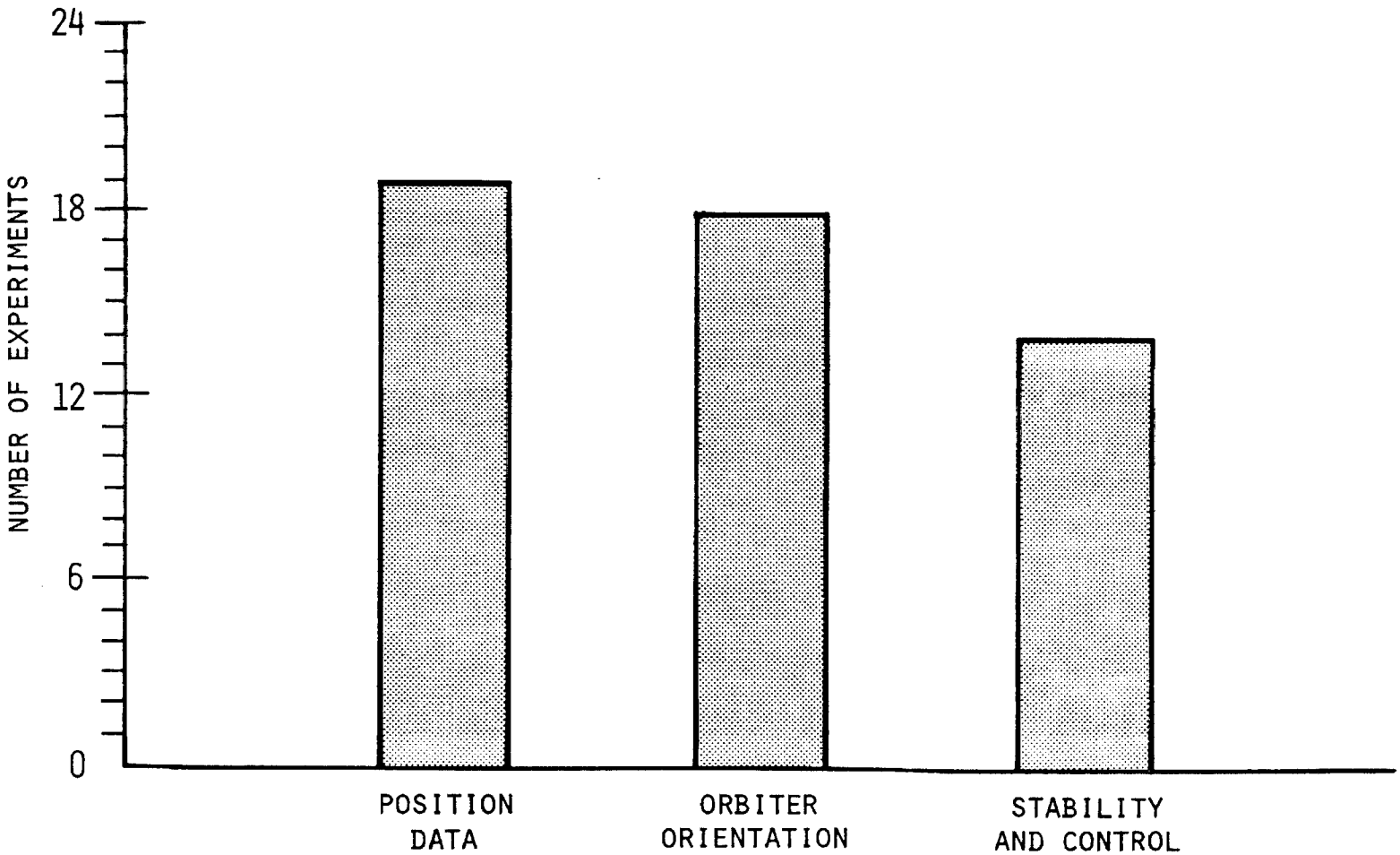
## MISSION INTEGRATION ANALYSIS

An analysis of the 24 baseline experiments was performed to determine the need for mission integration. The analysis addressed user's needs in terms of Orbiter maneuvering, stability and control and knowledge of position. Results of the analysis indicates that 18 experiments require Orbiter maneuvers, 14 require attitude stabilization and 19 experiments require knowledge of position.

These results, as depicted on the facing page, show that mission integration is required in the Quick-Reaction concept.

# MISSION INTEGRATION ANALYSIS

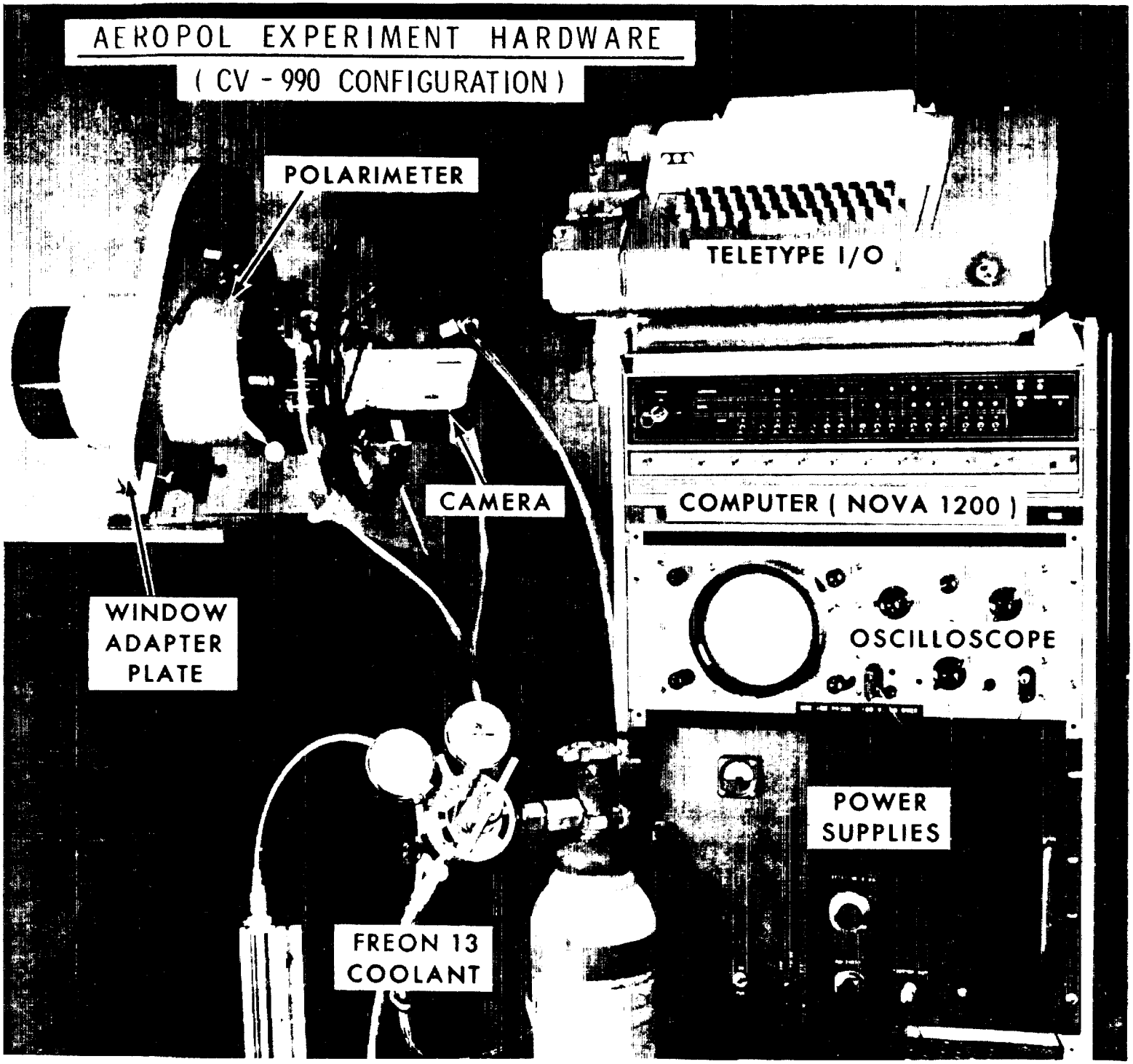
ANALYSIS OF 24 CANDIDATE EXPERIMENTS




TRW SYSTEMS GROUP

## AEROPOL (CV-990 CONFIGURATION)

The photograph on the facing page shows the AEROPOL experiment hardware as it was flown on the NASA Ames CV-990 aircraft. As an example in Phase 2, the same experiment, in a modified configuration, was used to illustrate the integration concept. The modification consisted of deleting the teletype input/output, the NOVA 1200 computer and the oscilloscope and, in their place, utilizing the Sortie Lab Data Management System. For the action item, the experiment configuration was to be the same as indicated in the photograph, i.e., the autonomous configuration. In this example, it is assumed that the commercial equipment that is part of the experiment hardware is space flight rated to preclude additional qualification testing.




ORIGINAL PAGE
BLACK AND WHITE PHOTOGRAPH

TRW

## AEROPOL (UNMODIFIED)

The integration requirements for the autonomous AEROPOL are presented. Basically, the hardware integration requirement is the same as for the modified AEROPOL presented in Phase 2. The same adapter fitting is required for the polarimeter. The rack mounting of the support equipment is an additional requirement but does not present a large impact.

The greatest difference is reflected in the software area. Since the experiment includes its own computer, software integration requirements are minimal, those being the processing of data through the Sortie Lab DMS for magnetic tape recording.

Mission requirements are not changed by the configuration change. The scientific objectives dictate mission requirements in this case.

In summary then, the only significant change in integration requirements between the two configurations is a reduction in software integration requirements.

## AEROPOL (UNMODIFIED)

### INTEGRATION REQUIREMENTS

HARDWARE - DESIGN AND FABRICATE MOUNTING ADAPTER HARDWARE.

SOFTWARE - DATA RECORDING ON DMS RECORDERS.

MISSION - ORBITER ROLL ATTITUDE TO POSITION VIEWPORT/INSTRUMENT TOWARD EARTH FOR CLOUD OBSERVATIONS. POINTING ACCURACY $\pm 0.5^{\circ}$.

TRW SYSTEMS GROUP

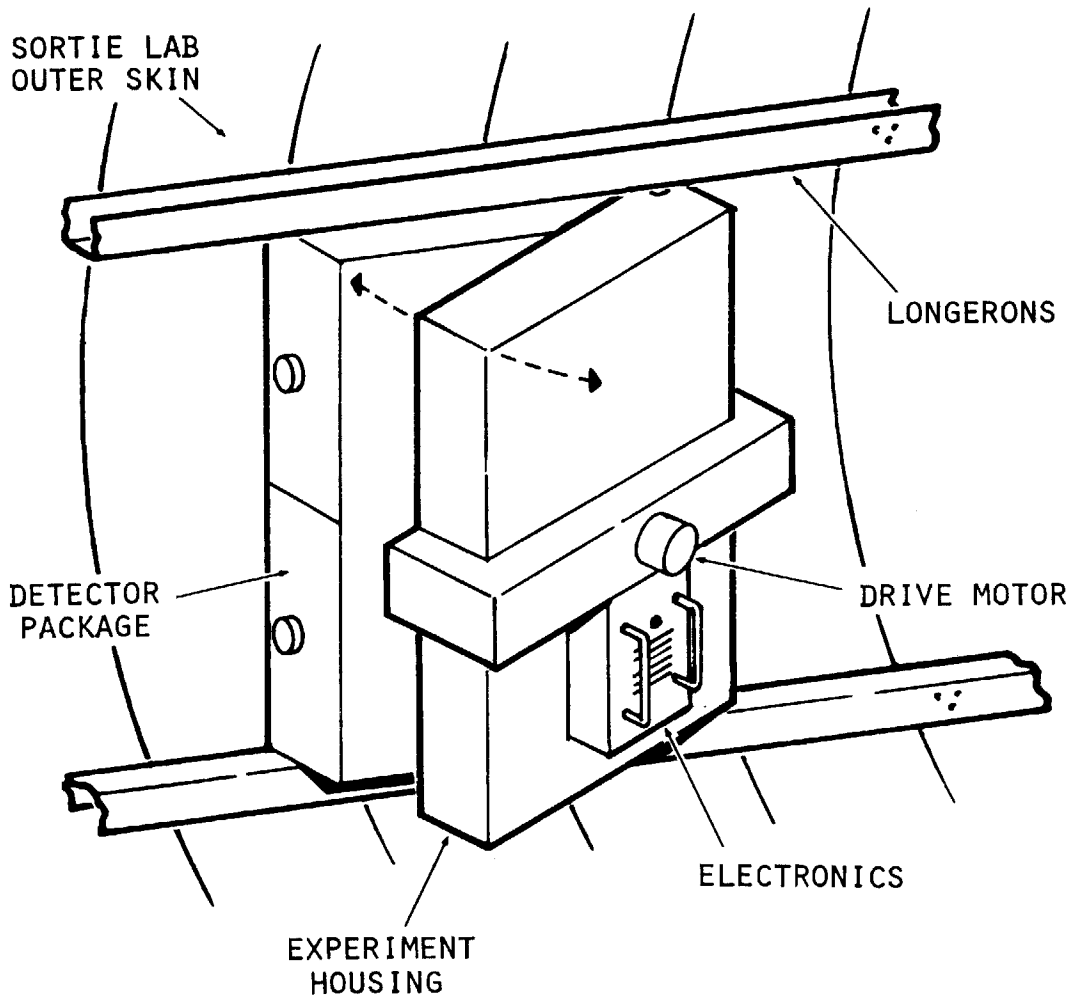
## PLASTIC/NUCLEAR EMULSION

The Plastic/Nuclear Emulsion Experiment is shown on the facing page. This experiment was chosen from the baseline experiment list as an example of simplicity in operation and integration.

The experiment comprises a detector package which contains the emulsion elements and an experiment housing containing the drive motor and electronics.

The experiment is completely automated in operation, with the emulsion sheets automatically exposed at prescribed intervals by a timed sequencer. The electronics panel gives provisions for resetting the timer and initiating a new sequence, as well as providing electrical power control to the Sortie Lab by an on/off switch adjacent to the outer skin.

# PLASTIC / NUCLEAR EMULSION




TRW

## PLASTIC/NUCLEAR EMULSION
### Integration Requirements

The integration requirements for the Plastic/Nuclear Emulsion Experiment are presented on the facing page.

Hardware integration requirements include the design and fabrication of adapter hardware to mount the experiment next to the Sortie Lab outer skin.

No software requirements exist for this experiment, since all data is in the form of emulsion sheets.

No specific Orbiter maneuvers are required since any attitude in the zenith hemisphere is sufficient during exposure times. Therefore, mission integration requirements are minimized to knowledge of position only.

# PLASTIC/NUCLEAR EMULSION

## INTEGRATION REQUIREMENTS

HARDWARE - DESIGN AND FABRICATE MOUNTING ADAPTER HARDWARE.

SOFTWARE - NO SOFTWARE REQUIREMENTS - DATA IN FORM OF EMULSION SHEETS.

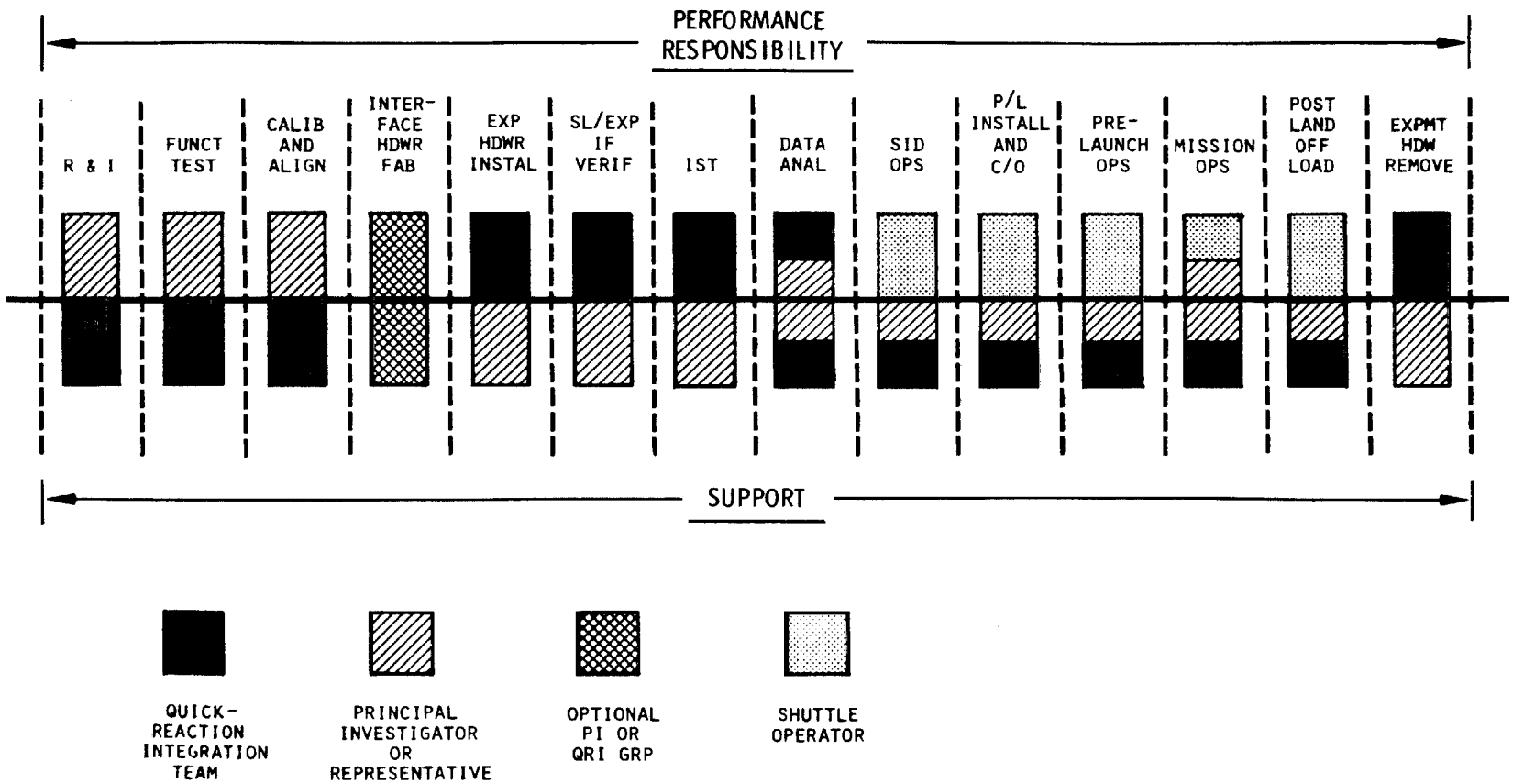
MISSION - NO MANUEVERING REQUIRED, i.e., ANY ATTITUDE IN ZENITH HEMISPHERE MUST HAVE KNOWLEDGE OF POSITION WITHIN $\pm 1^0$ (POINTING ACCURACY).

TRW

## USER INVOLVEMENT

The facing page depicts user involvement in the integration and test tasks, through the mission, to postlanding operations. In general, once experiment hardware installation into the Sortie Lab has begun the Quick-Reaction integration team, or the Shuttle Operator for Orbiter-related tasks, has the performance responsibility. This is due to the overall system nature of the task. The principal investigator or his representative still has primary responsibility for his experiment but the aggregate users perform a support function to the Quick-Reaction team during Sortie Lab/Integrated experiment payload systems test. The underlying theme is that the principal investigator retains responsibility for his experiment throughout the mission.

# USER INVOLVEMENT




( PI RETAINS RESPONSIBILITY FOR HIS EXPERIMENT THROUGHOUT MISSION )

TRW

## USER'S SURVEY

A survey of a limited number of potential users was conducted to obtain a broader base of opinion with respect to participation in the Quick-Reaction Sortie Program.

The ten potential users responding to the questionnaire are listed on the facing page along with their affiliation and experiment or discipline.

The questionnaire used for the survey is described in detail in the Appendix. Basically, the questionnaire covered those functions pertaining to software and mission requirements.

# USER'S SURVEY

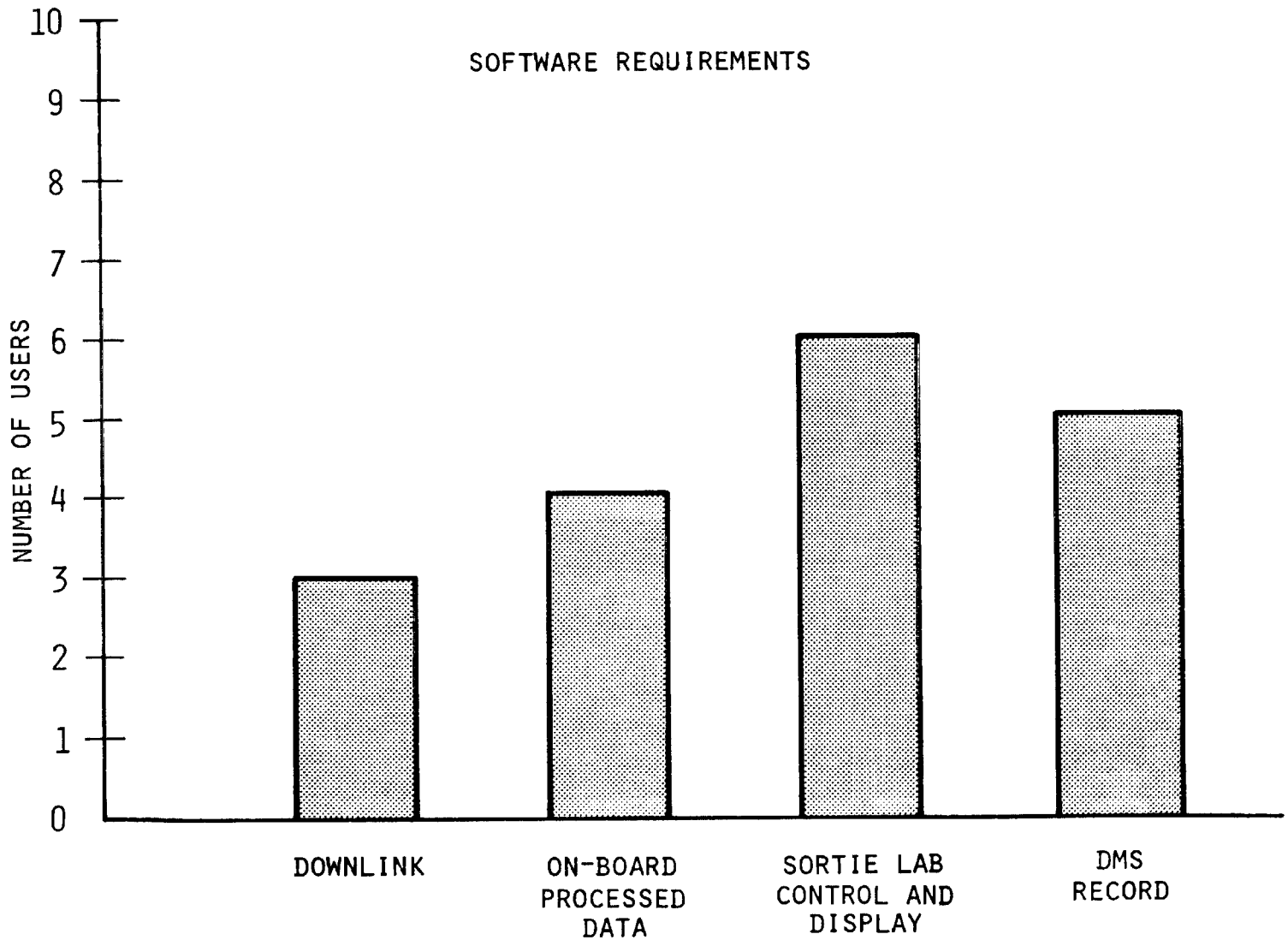
| | | |
|---|---|---|
| T. WILHEIT | GSFC | MICROWAVE RADIOMETER |
| F. BARATH | JPL | MICROWAVE SPECTROSCOPY |
| B. ERB | MSC | MULTISPECTRAL CAMERA |
| A. WILLIAMSON | ARMY CORP OF ENGRS. | REMOTE SENSING/IMAGING DEVICES |
| P. KRUMPE | U. OF CALIFORNIA | REMOTE IMAGING/SCANNING |
| D. COFFEEN | LUNAR AND PLANETARY LAB<br>U. OF ARIZONA | POLARIMETER/PHOTOMETRY |
| L. LEPLEY | OFFICE OF ARID LANDS<br>U. OF ARIZONA | MULTISPECTRAL POLARIMETRY<br>SIDE-LOOKING RADAR |
| P. SLATER | OPTICAL SCIENCES CNTR<br>U. OF ARIZONA | EARTH RESOURCES/ASTRONOMY |
| C. FAN | DEPT. OF PHYSICS<br>U. OF ARIZONA | NEUTRAL/CHARGED PARTICLES |
| W. TIFFT | DEPT. OF ASTRONOMY<br>U. OF ARIZONA | UV SKY SURVEY |

TRW

## USER'S SURVEY RESULTS
### Software Requirements

Results of the user's survey with respect to software requirements are shown on the facing page. Of the 10 users surveyed, 3 prefer to use the Orbiter downlink capability, 4 require on-board processed data (such as manipulation of raw data into engineering units), 5 would use the DMS tape recorders and 6 would require controls and displays. No software requirements are shown for those who wish to process their own data.

# USER SURVEY RESULTS



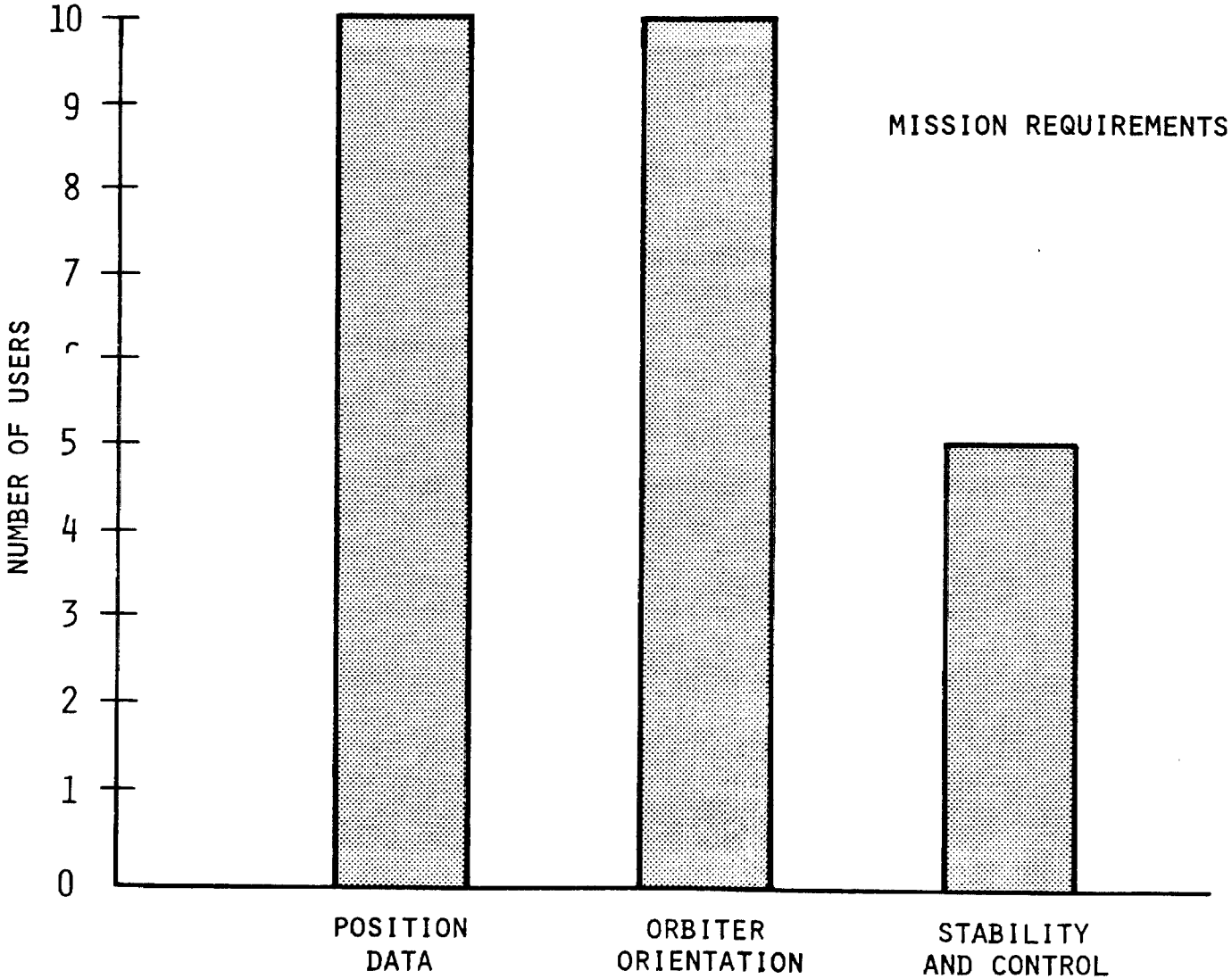

TRW

## USER'S SURVEY RESULTS
### Mission Requirements

The results of the user's survey with respect to mission requirements are shown on the facing page.

All of those surveyed required position data for initiation or sequencing of experiment operations, and Orbiter orientation or specific attitudes for targets or areas of interest. Only half required stability and control, i.e., to hold a specific attitude to some tolerance.

# USER SURVEY RESULTS




TRW

## USER'S SURVEY RESULTS

### General

Results of the survey indicate that there is a high interest in the Quick-Reaction Sortie concept. Many of the users have previously developed hardware, consequently, the relatively short time span of 1 to 3 months from hardware arrival at the integration site to receipt of data is attractive to them. In addition, many of the users prefer to fly with their experiment. This allows for simplicity in the design of the experiments and provides greater probability of success. All of those interviewed indicated a great desire for minimum paper-work.

# USER SURVEY RESULTS

GENERAL:

- HIGH INTEREST IN QUICK-REACTION SORTIE
- USER PREFERS TO FLY WITH EXPERIMENT
- STRESS MINIMUM PAPERWORK APPROACH

TRW SYSTEMS GROUP

## ALTERNATE HARDWARE/SOFTWARE INTEGRATION CONCEPT
### Assumptions

The Study Team was asked to examine the impact on the QR concept of pre-installation integration of a flight-qualified Payload Support Station (PSS) with the integrated Sortie Lab. This concept is most desirable if the payload computer is located in the PSS, per the SOAR Study recommendations; therefore, that assumption was made. Other assumptions relating to the feasibility of the concept are stated on the facing page.

## ALTERNATE HARDWARE / SOFTWARE INTEGRATION CONCEPT

### ASSUMPTIONS

- PAYLOAD COMPUTER WILL BE LOCATED IN PSS.
- SUFFICIENT SPARE FLIGHT PSS UNITS WILL BE MADE AVAILABLE
- INSTALLATION OF PSS IN ORBITER CAN BE ACCOMPLISHED WITHOUT IMPACTING TURN-AROUND SCHEDULES
- PSS WILL NOT REQUIRE EXTENSIVE RECERTIFICATION PRIOR TO INSTALLATION.

TRW

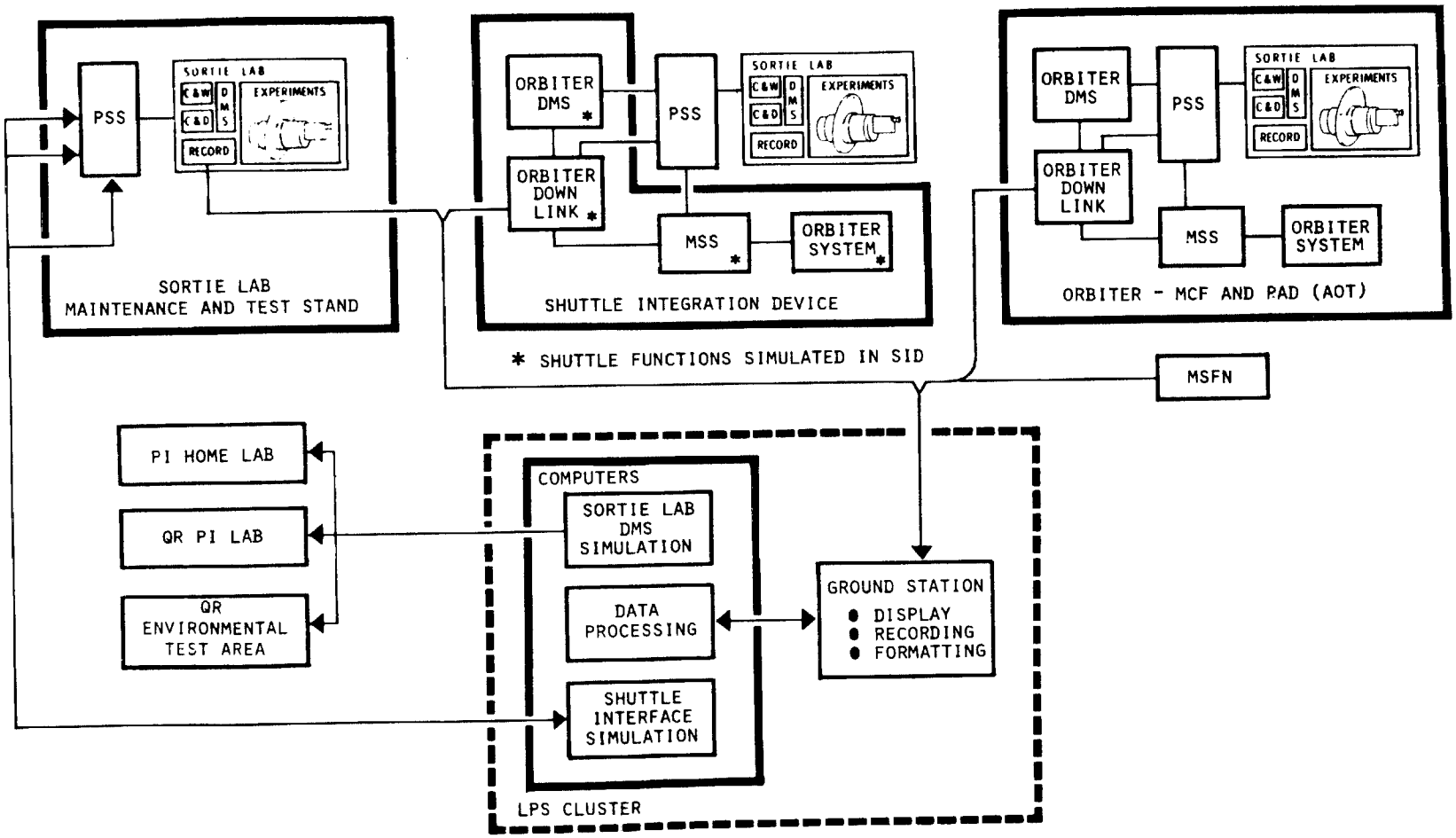
## ALTERNATE HARDWARE/SOFTWARE INTEGRATION CONCEPT

This is an abbreviated and modified version of the baseline software integration concept presented in Volume II, Page 3-55. The flight-qualified PSS is interconnected to the Sortie Lab in the Maintenance and Test Stand. The Shuttle data interface with the PSS is simulated by the LPS. Experiments are installed in the Lab and functional and integrated systems testing is performed for the entire configuration.

In the SID, the Shuttle interface is provided by near-flight hardware and/or simulations, and compatibility demonstration testing is performed. The PSS and Sortie Lab are then installed in the Orbiter, and the baseline test flow is followed from that point.

# ALTERNATE HARDWARE / SOFTWARE

## INTEGRATION CONCEPT



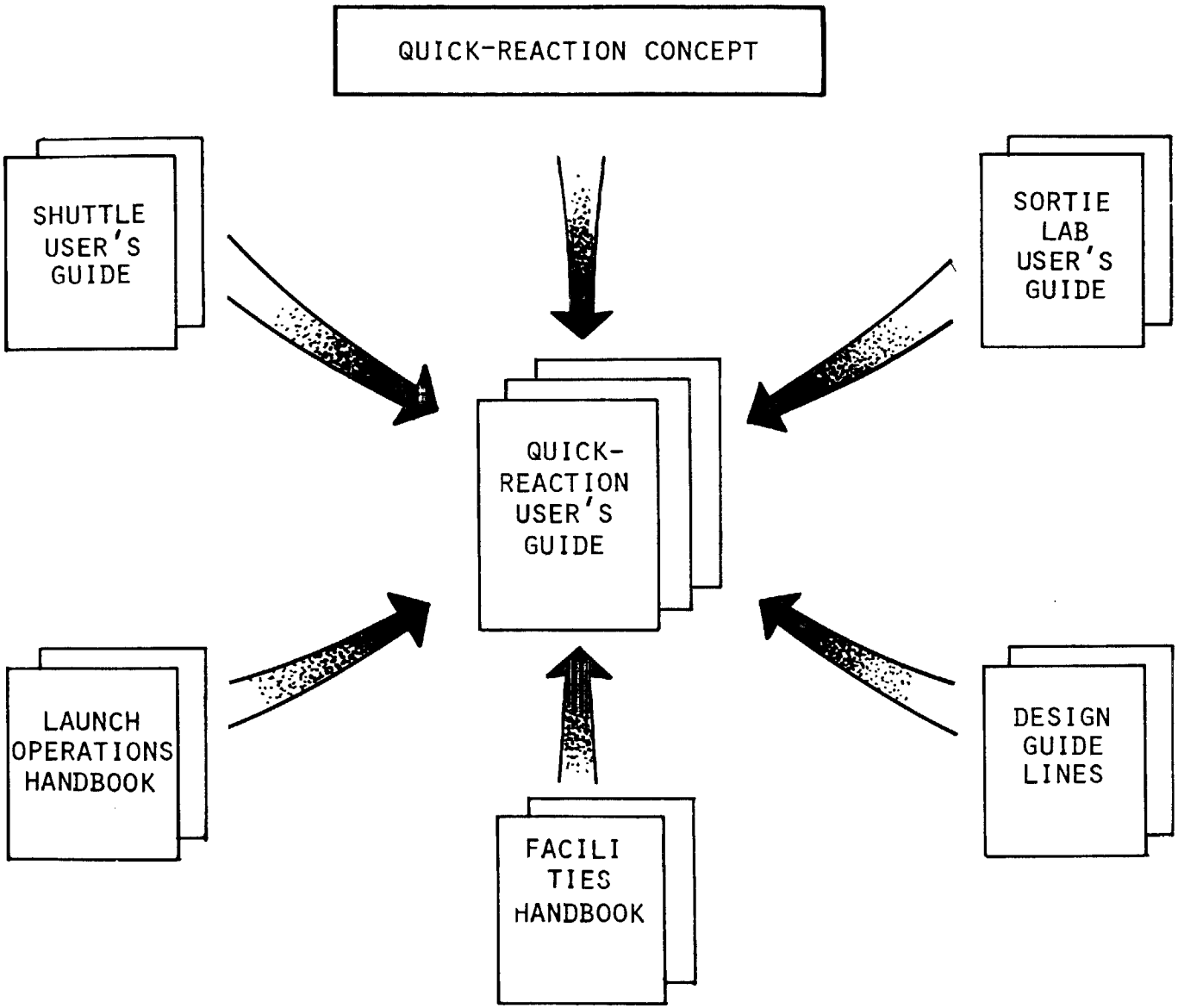

TRW

# 3.0 QR USER'S GUIDE

## QUICK-REACTION USER'S GUIDE

The chart on the facing page shows that, while encompassing the Quick-Reaction concept, the User's Guide is a compilation of portions of other documents that will most directly aid a user wishing to fly the Quick-Reaction Sortie Mode. It is conceivable that the Quick-Reaction User's Guide may be either a separate document or a subsection of one of the other User's Guides.

# QUICK - REACTION USER'S GUIDE

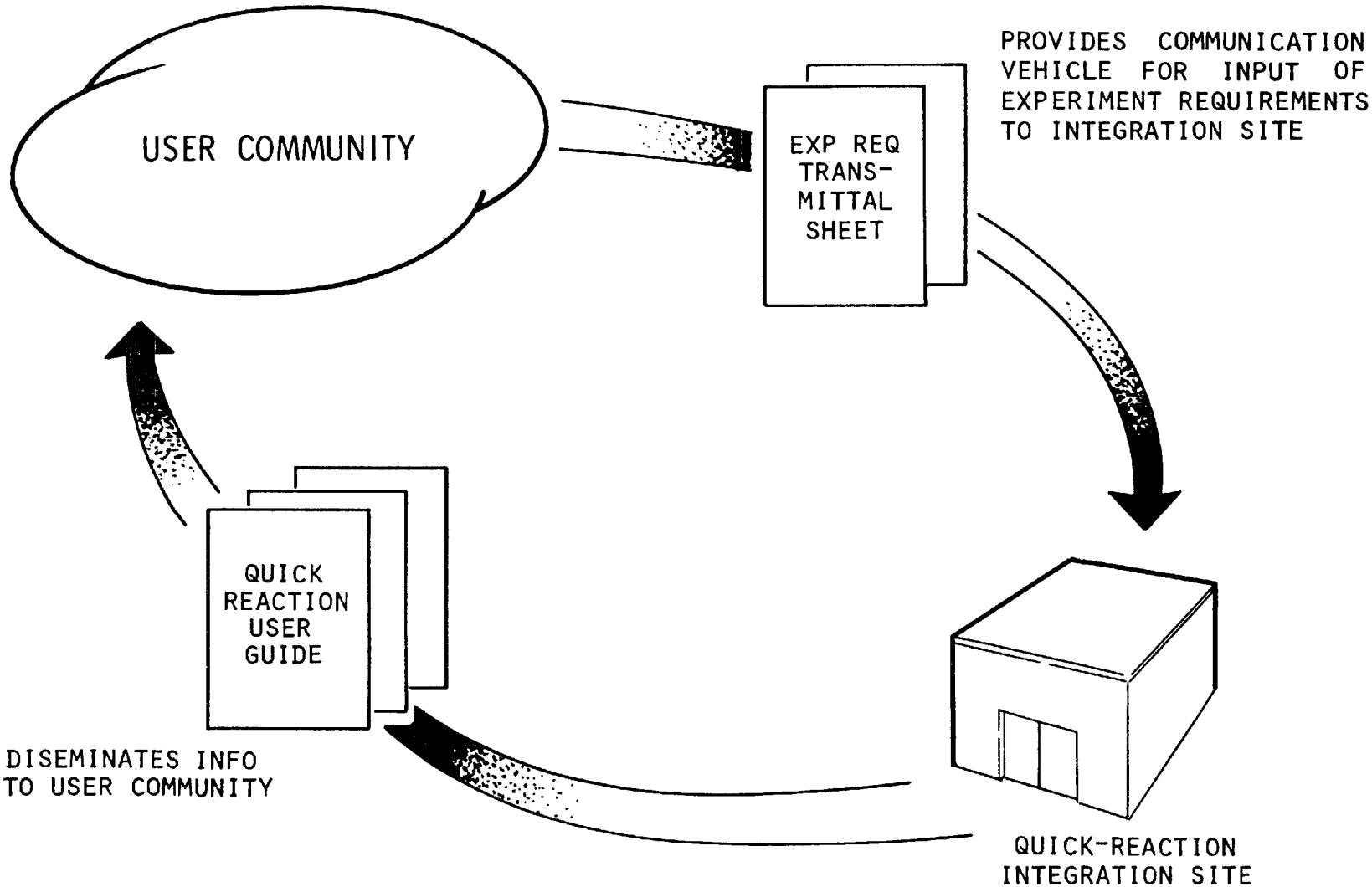



TRW SYSTEMS GROUP

## QUICK-REACTION USER'S GUIDE IMPLEMENTATION

Implementation of the QR User's Guide is depicted on the facing page. Like most guides or handbooks, the QR User's Guide disseminates information to the user community. In addition, through the use of experiment requirements transmittal sheets, the user can efficiently communicate with the Quick-Reaction Integration site. These sheets are included in the User's Guide as tear-outs.

# QUICK-REACTION USER'S GUIDE IMPLEMENTATION




TRW

## QUICK-REACTION USER'S GUIDE ELEMENTS

The QR User's Guide describes in general terms the Shuttle Program and, more specifically, the Quick-Reaction Sortie Mode and Sortie Lab subsystems. It describes in detail the facilities and support equipment available to the user at the integration site and further describes the mechanical and electrical Sortie Lab-to-experiment interfaces. In addition, the QR User's Guide aids in experiment design by referencing state-of-the-art design manuals and lists of acceptable or unacceptable materials for space flight hardware. Finally, the QR User's Guide provides experiment requirements transmittal sheets to forward the user's preliminary requirements to the Quick-Reaction integration site.

## QUICK–REACTION USER'S GUIDE ELEMENTS

DESCRIBES: SHUTTLE PROGRAM, QUICK-REACTION SORTIE MODE, SORTIE LAB SUBSYSTEMS, POLICY AND PROCEDURES ETC.

DELINEATES: FACILITIES, INTERFACES, SAFETY SPECS, QUALITY REQUIREMENTS AND SCHEDULES.

GUIDES: EXPERIMENT DESIGN, INTEGRATION REQUIREMENTS.

PROVIDES: EXPERIMENT REQUIREMENTS TRANSMITTAL SHEETS

TRW

## CONTENTS OF QUICK-REACTION USER'S GUIDE

The contents of the User's Guide is shown on the facing page. A more detailed description of the contents can be found in the Appendix.

# CONTENTS OF QUICK-REACTION

## USER'S GUIDE


1.0 INTRODUCTION

2.0 FACILITIES

3.0 SCHEDULES

4.0 SAFETY SPECS

5.0 SPACE FLIGHT QUAL. REQUIREMENTS

6.0 INTEGRATION REQ.

7.0 EXP. TO SORTIE LAB INTERFACES

8.0 EXP. DESIGN REF.

9.0 RANGE SUPPORT AND REQUIREMENTS

10.0 LAUNCH OPERATIONS AND PROCEDURES

11.0 FLIGHT OPERATIONS

12.0 POST-FLIGHT OPS

13.0 PROPOSALS

14.0 FINANCIAL AND LEGAL ASPECTS

15.0 EXP. REQUIREMENTS TRANSMITTAL FORMS


TRW

## EXPERIMENT REQUIREMENTS TRANSMITTAL FORM

The experiment requirements transmittal sheet shown on the facing page is envisioned as a tear-out sheet(s) in the Quick-Reaction User's Guide. It is intended to provide a convenient method for the user to communicate his preliminary experiment requirements to the Quick-Reaction integration site so that an efficient integration operation can be performed within the time frame, 1-3 months, of the Quick-Reaction concept.

# EXPERIMENT REQUIREMENTS TRANSMITTAL FORM

PURPOSE

TO PROVIDE CONVENIENT AND EFFICIENT MEANS OF CONVEYING USER'S REQUIREMENTS TO THE QUICK-REACTION INTEGRATION SITE.

OBJECTIVE

TO OBTAIN PRELIMINARY INFORMATION FOR EARLY PREPARATION OF USER LABORATORIES AND TO INITIATE COMMUNICATIONS WITH USER THUS MAINTAINING THE QUICK-REACTION PROFILE.

EXPERIMENT REQUIREMENTS TRANSMITTAL SHEET

EXPERIMENT DESCRIPTION: _____

_____

_____

WEIGHT (INCL. FLT SUPPORT EQUIP): _____

ELECT. POWER: AVG ____ PEAK ____ REGULATED _____

COOLANT: _____

DATA REQUIREMENTS: ON-BOARD PROCESSING _____
TELEMETRY _____ RECORDING _____ BIT RATE _____

MISSION REQUIREMENTS: SPECIFIC ATTITUDE _____
POINTING ACCURACY _____ PERIODS OF OPERATION
_____

FACILITIES: LABORATORY AREA _____ SQ. FT.
CEILING HEIGHT _____ SPECIAL LIGHTING _____
CLEANLINESS CLASS _____ RF ENVIRONMENT _____
COMMODITIES: GAS WATER
CRYOGENICS

SUPPORT SERVICES: PHOTOGRAPHIC TEST AND

TRW SYSTEMS GROUP

# 4.0 LAUNCH SITE IMPACT

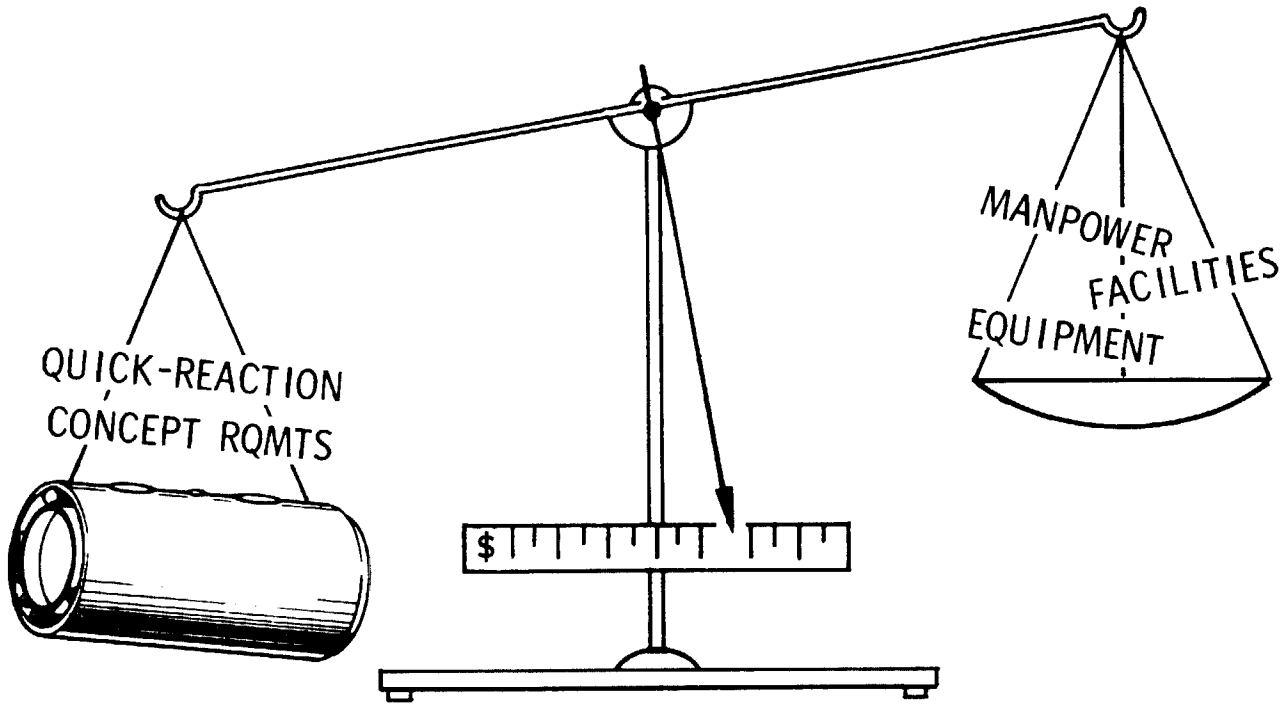
## LAUNCH SITE IMPACT

Program impact on the launch site generally affects the areas of facilities, equipment, manpower, etc. The launch site impact due to the Quick-Reaction concept was determined by comparing the program requirements to the available resources. Certain ground rules and assumptions were necessary to guide this analysis:

- Make maximum use of existing facilities
- Four Quick-Reaction flights per year
- One Sortie Lab vehicle assigned to the Quick-Reaction activity
- Quick-Reaction ground operations are on a one shift basis

As the chart on the facing page implies, the introduction of a new program at the launch site usually results in some new costs. The charts that follow indicate the requirements and their estimated costs in the areas of facilities and equipment. The manpower impact is shown later in the section of this report entitled, "QR Organization".

# LAUNCH SITE IMPACT




- MAKE MAXIMUM USE OF EXISTING FACILITIES
- FOUR QR FLIGHTS PER YEAR IS BASELINE
- ONE QR SORTIE LAB VEHICLE
- SINGLE SHIFT OPERATIONS

TRW
SYSTEMS GROUP

## LAUNCH SITE IMPACT

The gross requirements for the Quick-Reaction activity at the launch site are shown on the facing page. A brief explanation of each requirement follows. More detailed information is contained in the Appendix.

The Sortie Lab assigned to the Quick-Reaction Program requires about 10,000 square feet (SF) of space for the maintenance, test and checkout activities necessary to prepare it for flight. This includes the space necessary for a Maintenance and Test Stand, work platforms, an adjacent technician work area, tool room, storage, etc.

Six PI Labs are required, one for each of the six experiment groups identified earlier in this study. The total amount of space required is estimated to be 7500 SF.

An Environmental Qualification Laboratory is required to perform flight qualification tests on those experiments that arrive at the launch site unqualified. This lab contains shake tables, thermal-vacuum chamber, and peripheral equipment.

Since the Quick-Reaction Sortie Lab is owned, operated and fully integrated at the launch site by the Shuttle Operator (this is defined as the NASA Center responsible for Shuttle ground operations) a complete set of Sortie Lab GSE and ground servicing systems are required. Similarly, since the Quick-Reaction experiment labs are new to KSC, complete outfitting is required suitable for each of the experiment groups. This outfitting includes standard laboratory equipment. It is expected that the unique equipment associated with the experiments will be brought in by the PI's from their home labs.

In the time frame being considered, the LPS at KSC will be operational; consequently, only equipment that is added to the LPS to handle the Quick-Reaction activity is considered.

# LAUNCH SITE IMPACT

FACILITY REQMTS:

- QRSL - 10,000 SF WORK AREA
- PI LABS - 7500 SF
- ENVIR QUAL LAB - 2000 SF

GROUND SUPPORT EQUIP RQMTS:

- QRSL - ALL GSE AND SYSTS
- PI LABS - COMPLETE OUTFITTING
- LPS - EQUIPMENT FOR QR ACTIVITY ADD-ON

MANPOWER RQMTS:

- DEDICATED QRIA CREW

TRW SYSTEMS GROUP

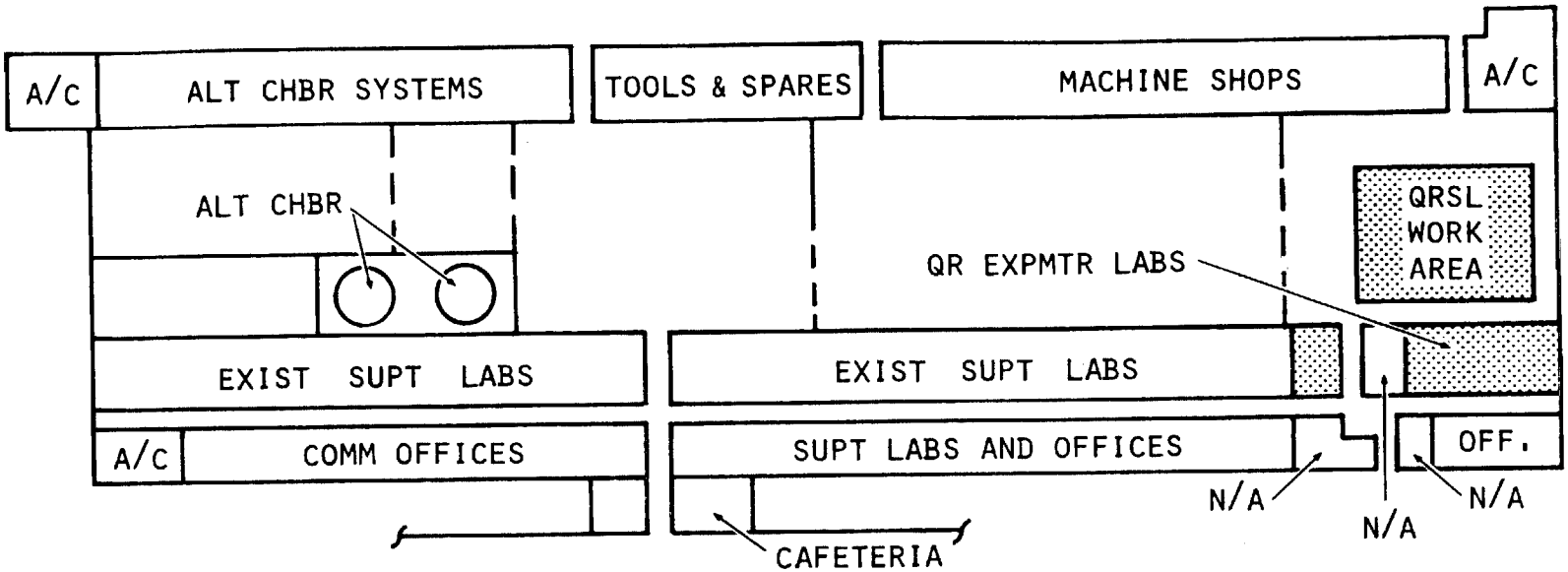
## LAUNCH SITE IMPACT

Of the existing facilities that could be utilized for the Quick-Reaction integration activities at the launch site, the existing Manned Spacecraft Operations (MSO) building (also called Operations and Checkout building) offers the best capability. Placing the QR Sortie Lab work area in the former Apollo Lunar Module area of the MSO with the local PI laboratories in adjacent lab areas is recommended. The close proximity of the PI labs to the Sortie Lab work area allows the PI's and the QR integration team to closely and efficiently coordinate the test, checkout, fit checks and integration activities that must be performed at the launch site.

The modifications to these areas are relatively minor since the MSO building was originally designed to handle spacecraft in a clean atmosphere. The high bay area can achieve a class 100,000 atmosphere. The PI labs require some modification to the ducting and additional filtration to meet class 100,000 cleanliness. Partitions and airlocks are also required in these areas.

An alternate location was also investigated. During the time frame the QR Program will be at KSC, the existing Viking spacecraft building will be available (formerly the Pyrotechnics Installation Building - PIB). While sufficient floor space for the Sortie Lab work area exists, there is not enough space to accommodate the PI labs in the building. Since this facility is not as desirable as the MSO, its use was not considered further.

# LAUNCH SITE IMPACT




EXISTING MSO BLDG

- CLOSE PROXIMITY OF QRSL WORK AREA AND LOCAL PI LABS
- QRSL AREA OCCUPIES ONLY 20% OF MSO HIGH BAY
- ALTERNATE QRSL WORK AREA IS VIKING S/C BLDG-BUT NOT ADEQUATE TO INCLUDE PI LABS

TRW

## LAUNCH SITE IMPACT

The chart on the facing page indicates the estimated cost (in 1973 dollars) of the various facilities and ground support equipment. More detail as to how the costs were developed appears in the Appendix.

The facilities costs indicate the expenditures necessary to prepare or modify an existing facility to accommodate the equipment required to maintain, test and integrate a QR Sortie Lab and the QR experiments and to provide the utilities required for these activities. The cost shown for an Environmental Qualification Laboratory is based on providing a new facility suitable for that activity. The cost to modify an existing facility to this purpose may cost less; however, availability of a suitable facility could not be verified.

The cost estimate for ground support equipment is based on the assumption that since all QR Sortie Lab maintenance, test and integration is done at the launch site, a separate set of ground systems and GSE is required to support these activities. Because the Sortie Lab is operational in the time frame being considered, the GSE and ground systems are also considered to be operational and not of an R&D nature; consequently, the cost of such equipment is lower. These costs reflect simply ordering an additional set of this equipment.

The cost for the PI labs equipment is based on outfitting six labs with the normal type of standard laboratory equipment required for the kinds of experimental work anticipated. It is anticipated that specialized equipment will be brought to the launch site by the PI.

The LPS costs reflect the requirement to add only the equipment necessary to adapt the Quick-Reaction activity to an already operational LPS.

The equipment costs for outfitting the Environmental Qualification Lab are estimates for providing shake tables, thermal-vacuum chambers, etc.

# LAUNCH SITE IMPACT

## ESTIMATED COST

| | | |
|---|---|---|
| **FACILITIES:** | | |
| • QR SORTIE LAB | $250,000 | |
| • PI LABS | 325,000 | |
| • ENVIR QUAL LAB | 150,000 (if new) | |
| | | $725,000 |
| **GROUND SUPPORT EQUIPMENT:** | | |
| • QR SORTIE LAB | 450,000 | |
| • PI LABS AND EXPMTS | 250,000 | |
| • LPS | 200,000 | |
| • ENVIR QUAL LAB | 500,000 | |
| | | 1,400,000 |
| | TOTAL | $2,125,000 |

(SORTIE LAB VEHICLE COSTS NOT INCLUDED)

TRW SYSTEMS GROUP

# 5.0 QR ORGANIZATION

## QRIA ORGANIZATION

Two approaches to organizing the Quick-Reaction Integration Activity at the launch site were developed:

- An autonomous organization that performs all functions required including Sortie Lab maintenance and checkout

- An abbreviated organization that takes advantage of the permanent Sortie Lab crew stationed at the launch site to perform Level I maintenance, servicing and checkout.

Each of the organizational approaches utilizes the institutional base support services available such as food, medical, communications, etc. In addition, the abbreviated organization utilizes some capability of the Shuttle Operators organization.

For this study the term "Shuttle Operator" refers to the NASA center responsible for Shuttle turnaround operations.

# QRIA ORGANIZATION

TWO APPROACHES:

- AUTONOMOUS QRIA ORGANIZATION PLUS INSTITUTIONAL BASE SUPPORT
- ABBREVIATED QRIA ORGANIZATION UTILIZING EXISTING LAUNCH SITE SL OPERATIONS PERSONNEL AND INSTITUTIONAL BASE SUPPORT

TRW

## QRIA ORGANIZATION

The Work Breakdown Structure (WBS) on the facing page shows the specific functions that comprise QRI operations. These functions are grouped under six major headings at the fifth level.

In many instances the functions shown are minor in nature; nevertheless, they are essential. Not all of the functions must be performed for all experiments.

# QRI CONCEPT - WORK BREAKDOWN

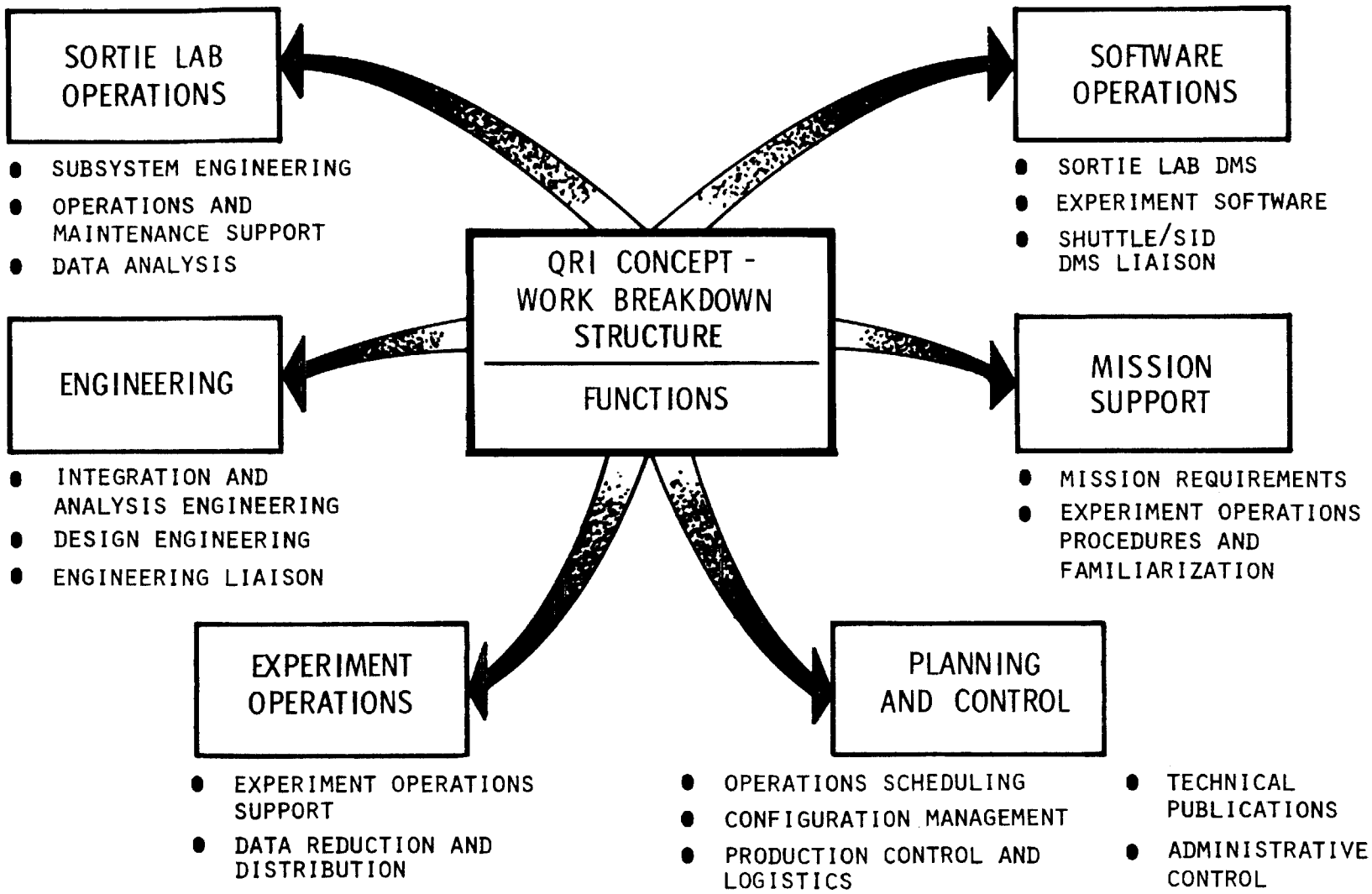
4 QUICK - REACTION PAYLOAD OPERATIONS

| 5 | QRI PLANNING & CONTROL | INTEGRATION ENGINEERING | SORTIE LAB MAINTENANCE & MODIFICATION | EXPERIMENT INTEGRATION & TEST | EXPERIMENT SOFTWARE INTEGRATION | QR MISSION INTEGRATION |
|---|---|---|---|---|---|---|
| 6 | PLANNING | ANALYSIS | SUBSYSTEM MAINTENANCE | INTERFACE HARDWARE FABRICATION | SORTIE LAB DMS SIMULATION DEVELOPMENT & MAINTENANCE | FLIGHT ASSIGNMENT ANALYSIS SUPPORT |
| | SCHEDULING | DESIGN | SUBSYSTEM TEST & C/O | HARDWARE INSTALLATION | PROVIDE SHUTTLE DMS SIMULATION | EXPERIMENT FLIGHT OPERATIONS REQUIREMENTS |
| | CONFIGURATION CONTROL | SAFETY & COMPATIBILITY SPEC REVIEW | SYSTEM C/O | INTEGRATION & TEST | PI SOFTWARE DEVELOPMENT LIAISON | EXPERIMENT FLIGHT OPERATIONS PROCEDURES |
| | DOCUMENT CONTROL | TEST REQUIREMENTS | MODIFICATION | DATA ANALYSIS & EVALUATION | SHUTTLE FLIGHT SOFTWARE LIAISON | FLIGHT OPERATOR FAMILIARIZATION |
| | ADMINISTRATION | ENGINEERING LIAISON | | POST-FLIGHT EXPERIMENT HARDWARE REMOVAL | EXPERIMENT-SORTIE LAB FLIGHT SOFTWARE VERIFICATION | |
| | LOGISTICS | | | TEST PROCEDURES | | |
| | MISSION MANAGEMENT | | | | | |

TRW SYSTEMS GROUP

## QRIA ORGANIZATION

A "first cut" at creating an organization from the WBS is presented. Six basic organizational elements are shown with the necessary sub-elements under each.


QRI CONCEPT - WORK BREAKDOWN STRUCTURE
FUNCTIONS
SORTIE LAB OPERATIONS
SUBSYSTEM ENGINEERING
OPERATIONS AND MAINTENANCE SUPPORT
DATA ANALYSIS
SOFTWARE OPERATIONS
SORTIE LAB DMS
EXPERIMENT SOFTWARE
SHUTTLE/SID DMS LIAISON
ENGINEERING
INTEGRATION AND ANALYSIS ENGINEERING
DESIGN ENGINEERING
ENGINEERING LIAISON
MISSION SUPPORT
MISSION REQUIREMENTS
EXPERIMENT OPERATIONS PROCEDURES AND FAMILIARIZATION
EXPERIMENT OPERATIONS
EXPERIMENT OPERATIONS SUPPORT
DATA REDUCTION AND DISTRIBUTION
PLANNING AND CONTROL
OPERATIONS SCHEDULING
CONFIGURATION MANAGEMENT
PRODUCTION CONTROL AND LOGISTICS
TECHNICAL PUBLICATIONS
ADMINISTRATIVE CONTROL

TRW

## QRIA ORGANIZATION

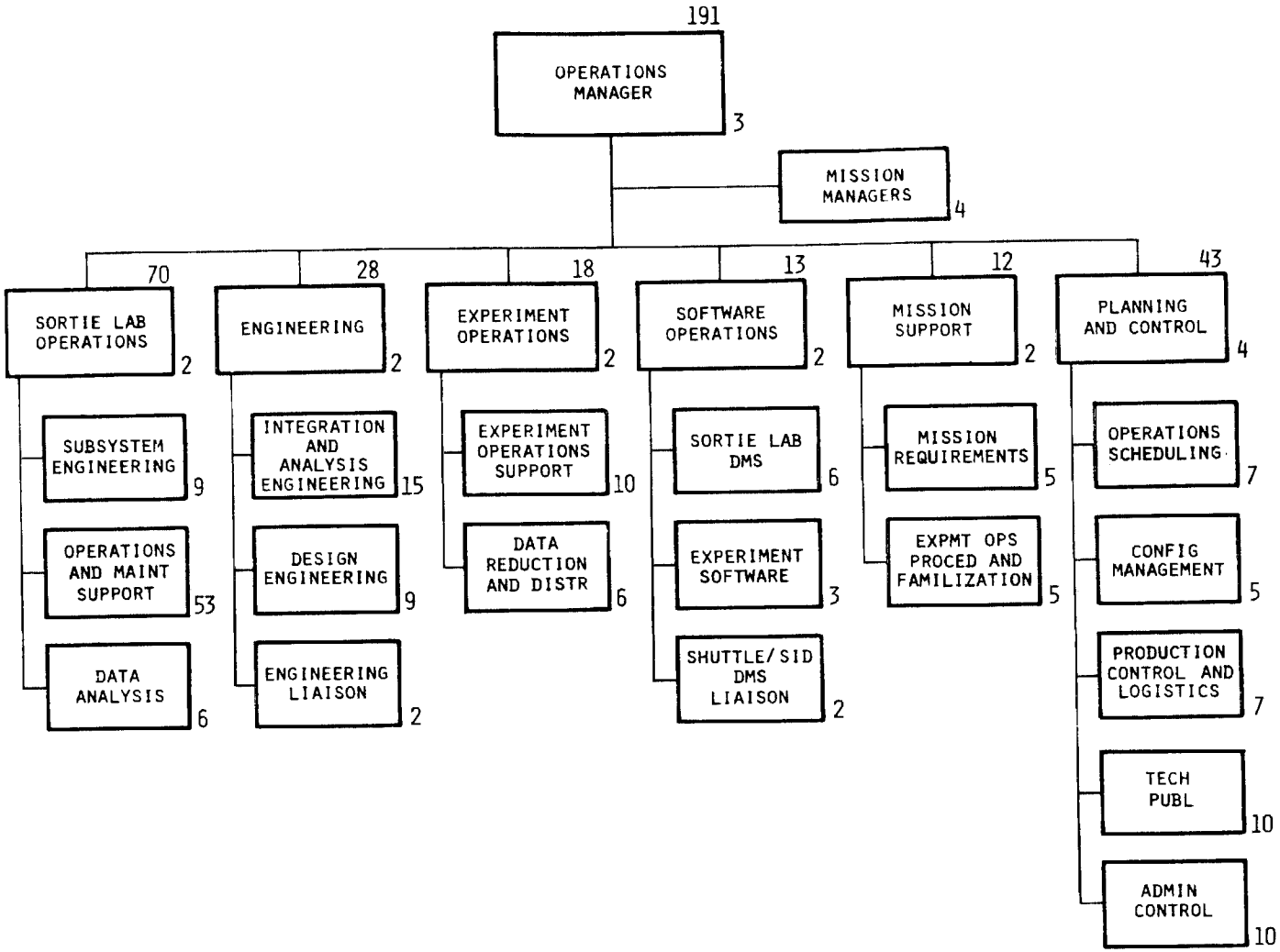
The autonomous organization is shown, based on 4 QR flights per year. Assigned manpower is noted at the lower right-hand corner of each box. The numbers shown on top of the management level boxes provide a subtotal of the people in that element of the organization. The total manpower estimated for the autonomous QRIA organization (191) is shown at the top of the Operations Manager box.

The Mission Managers are a staff function and operate across organizational lines. These managers are the single point of contact for the PI's at the launch site. Each Quick-Reaction flight has one mission manager. From the time a PI is approved and assigned to a specific flight, all of his requests, questions, etc. are directed to his assigned mission manager. This manager, in turn, arranges for all of the PI's needs with the other elements of the QRIA organization, the institutional base, etc.

No attempt has been made to distinguish between civil service and contractor personnel. Additional detail as to how these numbers were generated is shown in the Appendix.

# QRIA ORGANIZATION

AUTONOMOUS




TRW SYSTEMS GROUP

## QRIA ORGANIZATION

The second approach to QRIA organization takes advantage of the launch site location, which is baseline for this study.

The vertical dashed line designates a division of responsibility. The QRIA organization on the right handles those activities of an R&D nature associated with experiment integration activities. The organizations on the left are existing elements of the Shuttle Operators organization at the launch site.

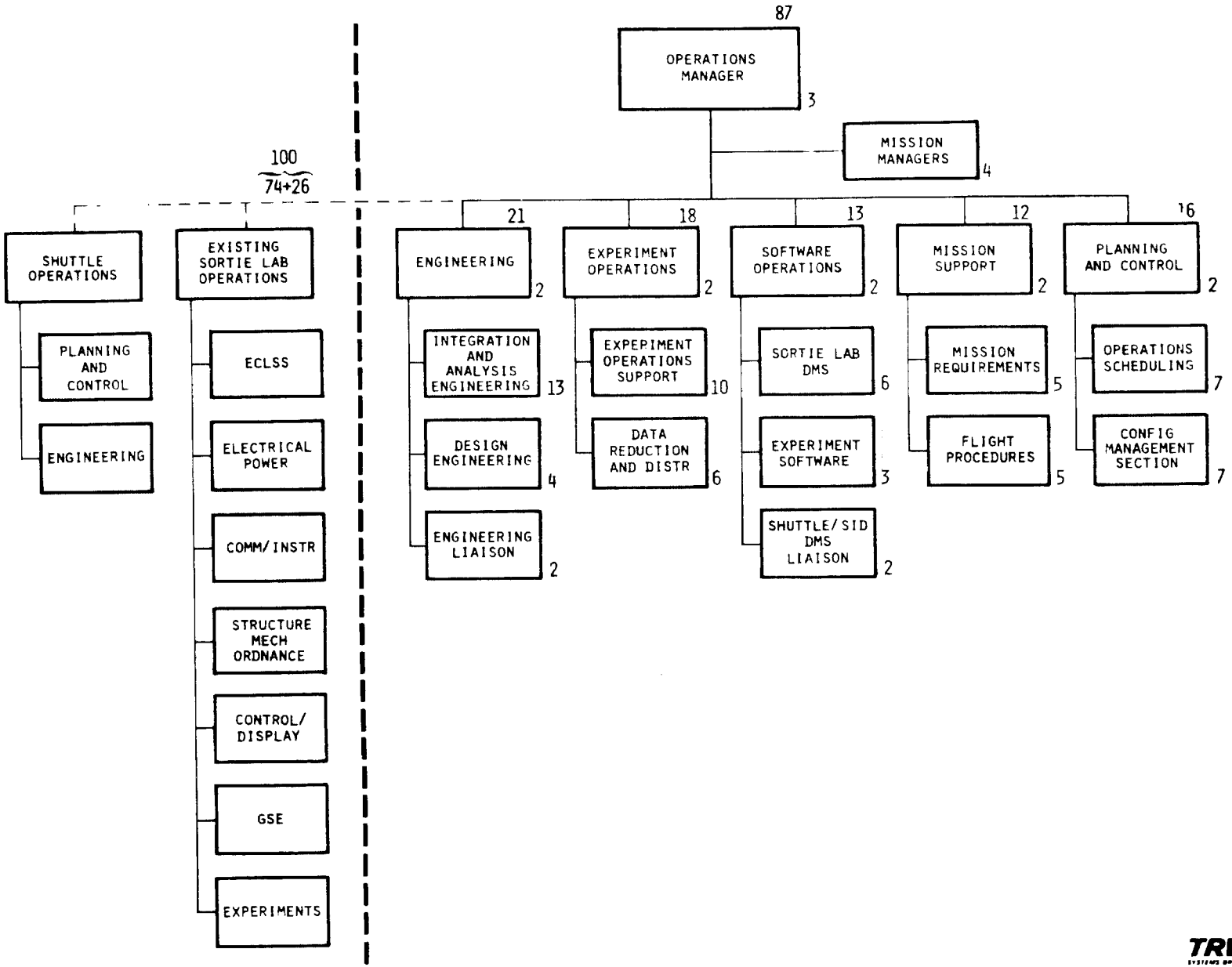
The QRIA abbreviated organization is staffed by 87 people. This reduction in personnel over the autonomous organization is possible because of efficiencies realized by utilizing an existing Sortie Lab operations team and relying on certain planning, control and engineering elements of the Shuttle Operators team.

The existing Sortie Lab operations team services and maintains the various Sortie Labs from other programs while at the launch site. Seventy-four people are planned for these operations. The breakdown of this crew is discussed in more detail on the next page. The QRIA analysis indicates that this crew must be supplemented by an additional 26 people to handle the additional 4 QR flights per year.

No quantities are provided for the Shuttle Operations personnel supporting the QRI activities since the organization for this activity has not been defined.

# QRIA ORGANIZATION

ABBREVIATED




TRW

## QRIA ORGANIZATION

The chart on the facing page indicates the purpose and composition of permanent Sortie Lab team located at the launch site. The information shown was obtained from current KSC planning.

# KSC PERMANENT SORTIE LAB TEAM

- THIS TEAM PART OF CURRENT KSC PLANNING
- PURPOSE: TO AUGMENT TRANSIENT CREWS AND SUPPORT ALL SORTIE LAB PROCESSING.
- FUNCTIONS:
  - LEVEL 1 MAINTENANCE
  - CHECKOUT AND SUPPORT
  - SERVICING
- COMPOSITION:

| | KSC ENGRS | OPER. ENGRS | TECHS |
|---|---|---|---|
| - ECLSS | 2 | 4 | 2 |
| - ELECTRIC PWR | 2 | 4 | 1 |
| - COMM/INSTR | 2 | 4 | 1 |
| - STRUCT/MECH/ORD | 1 | 2 | 2 |
| - CONTROL/DISPLAY | 1 | 2 | 1 |
| - GSE | 2 | 4 | 2 |
| - EXPERIMENTS | 3 | 6 | 1 |
| SUBTOTAL | 13 | 26 | 10 |
| - PLUS ADMIN, MGMT, ETC | 7 | 13 | 5 |
| TOTALS | 20 | 39 | 15 |

74

TRW

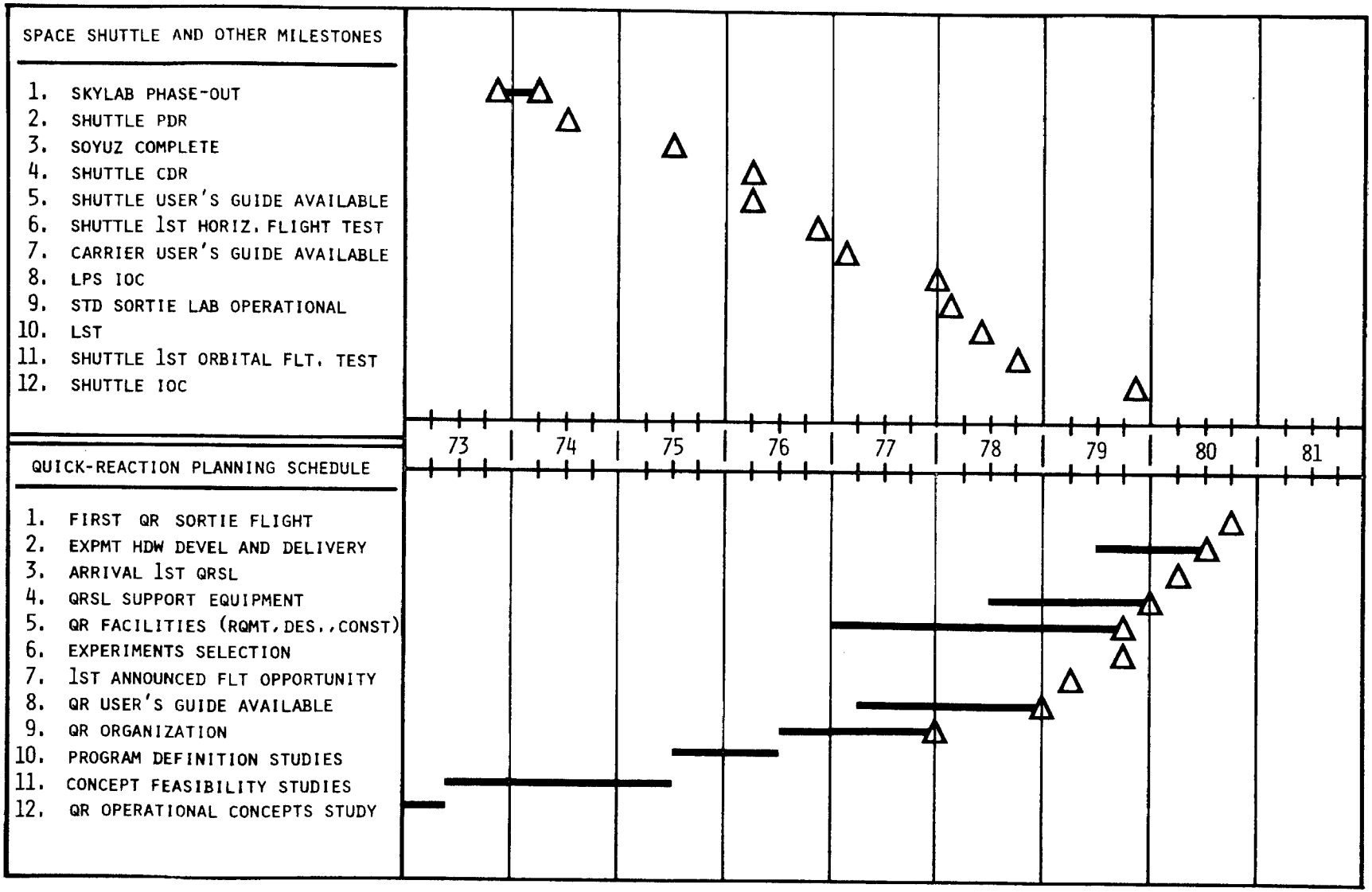
# 6.0 PLANNING SCHEDULES

## PLANNING SCHEDULES

This chart provides a visual way to relate the various activities associated with QRI planning to the Shuttle schedule and to other pertinent milestones. The Shuttle milestones are shown at the top of the chart. The triangles indicate the milestone date to the nearest calendar quarter.

The bottom of the chart contains milestone dates that were determined to be significant for the QR planning activities. Item 1, the first QR Sortie Flight, is shown occuring in the last quarter of 1980. This was arbitrarily selected; however, it is felt to be realistic. This flight occurs one year after Shuttle IOC which should allow sufficient time. The other QR planning activities are based on this date. The bars to the left of the triangles in this chart indicate the periods of time required to accomplish the particular activities. The triangles designate the time the activity is completed.

# QUICK - REACTION SORTIE CONCEPT PLANNING SCHEDULE




TRW

# 7.0 SENSITIVITY TO MISSION DENSITY

## SENSITIVITY TO MISSION DENSITY

The chart on the facing page reiterates some of the baseline assumptions for the study, and provides a list of additional assumptions that were necessary to perform the sensitivity analysis in a realistic manner.

Basically, the approach used in the analysis was to vary the number of QR Sortie Lab flights in a year and determine the effect of these variations. Two operational Orbiters at KSC were assumed because they could handle all of the anticipated QR flights. It was further assumed that there were no priority schedule conflicts with other payloads and that there were no contingencies that would require rescheduling.

# SENSITIVITY ANALYSIS

QUICK REACTION BASELINE CONCEPT -

- 4 QUICK-REACTION FLIGHTS PER YEAR
- 1 QUICK-REACTION SORTIE LAB
- SINGLE SHIFT OPERATIONS

ASSUMPTIONS FOR SENSITIVITY ANALYSIS -

- 2 OPERATIONAL ORBITERS
- 24 EVENLY SPACED SHUTTLE LAUNCHES PER YEAR
- 10 WORKING DAY GROUND TURN AROUND TIME FOR ORBITERS
- 7 CALENDAR DAYS FROM LAUNCH TO LAND
- NO PRIORITY CONFLICT WITH OTHER PAYLOADS

## SENSITIVITY ANALYSIS

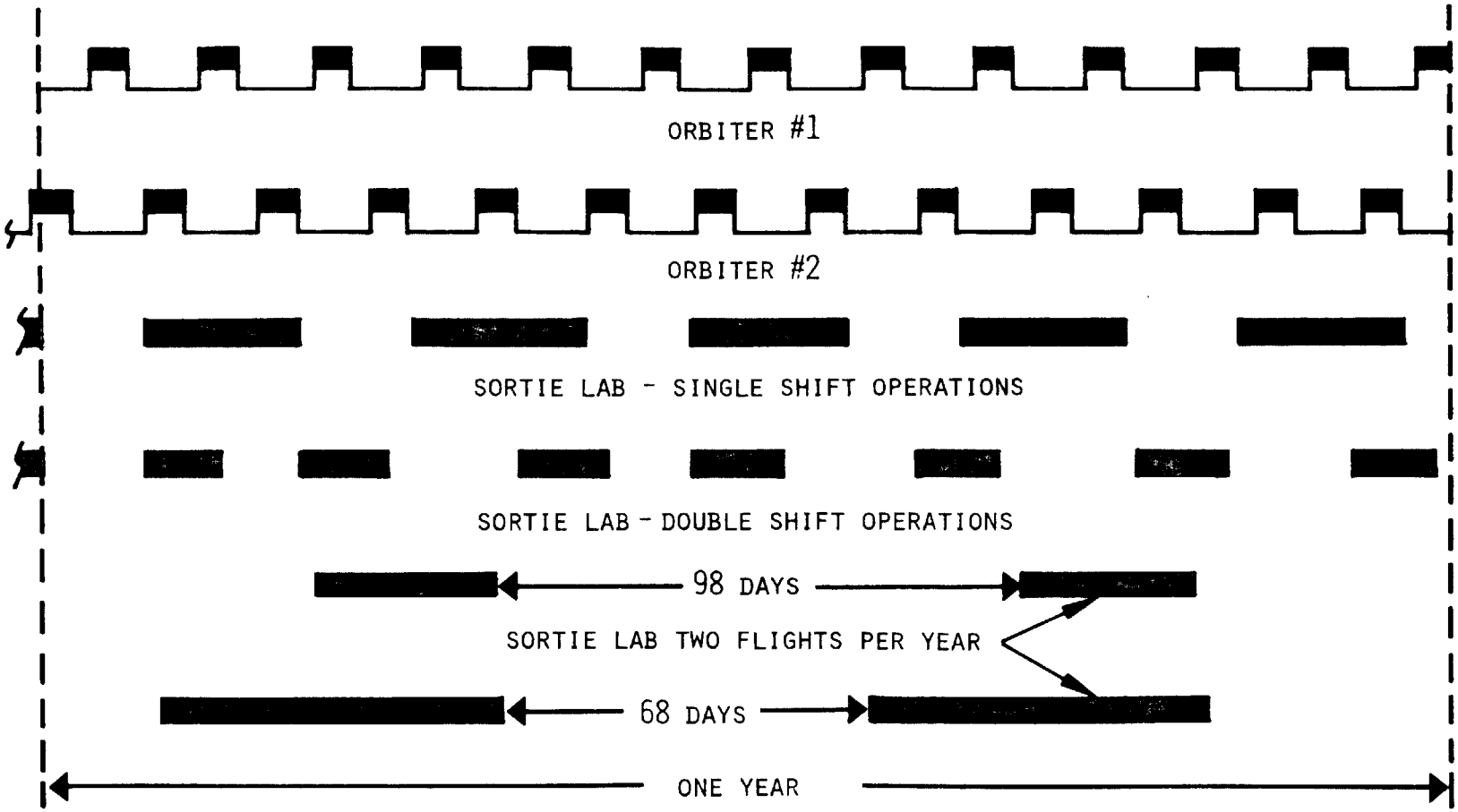
The chart on the facing page presents the sensitivity analysis results. The two top lines represent the two Orbiters, each flying, equally spaced, 12 times a year for a total of 24 flights per year. The raised bar on each line represents the 7 days from launch to land. The lower part of the line represents the Orbiter ground time.

The five bars for the Sortie Lab represent the ground operations time required to prepare a QR Sortie Lab for flight. The time was obtained from a time-phased functional flow diagram developed in Phase 1 of this study. A condensed version of this flow diagram is shown on the next page. The detailed flow diagram is included in the Appendix volume for this study.

Assuming that when the QR Sortie Lab is ready to fly it can be placed on the first available Orbiter with zero impact on the Orbiter flight schedule, the analysis shows that five QR Sortie Labs can be flown per year. With the same assumptions as above except using a two shift operation for the QR Sortie Lab, seven QR flights can be achieved in a year. These figures reflect using only a single Sortie Lab and flying it repeatedly. If another Sortie Lab is assigned to the QR Program, then more flights can be accomplished each year. However, the facilities, equipment and manpower must be significantly increased. Consequently, the costs increase. This analysis did not proceed past the point where additional resources are required.

The bars for the Sortie Lab at the bottom show two flights per year. The top bar indicates 98 days between QR flights when the same length of time for the Sortie Lab ground operations is used as was used above. The lower line shows 68 days between flights when the Sortie Lab ground operations time is stretched out (essentially doubled).

# SENSITIVITY ANALYSIS




- SINGLE SHIFT OPERATIONS - MAX. 5 FLIGHTS/YEAR
- DOUBLE SHIFT OPERATIONS - MAX. 7 FLIGHTS/YEAR

TRW SYSTEMS GROUP

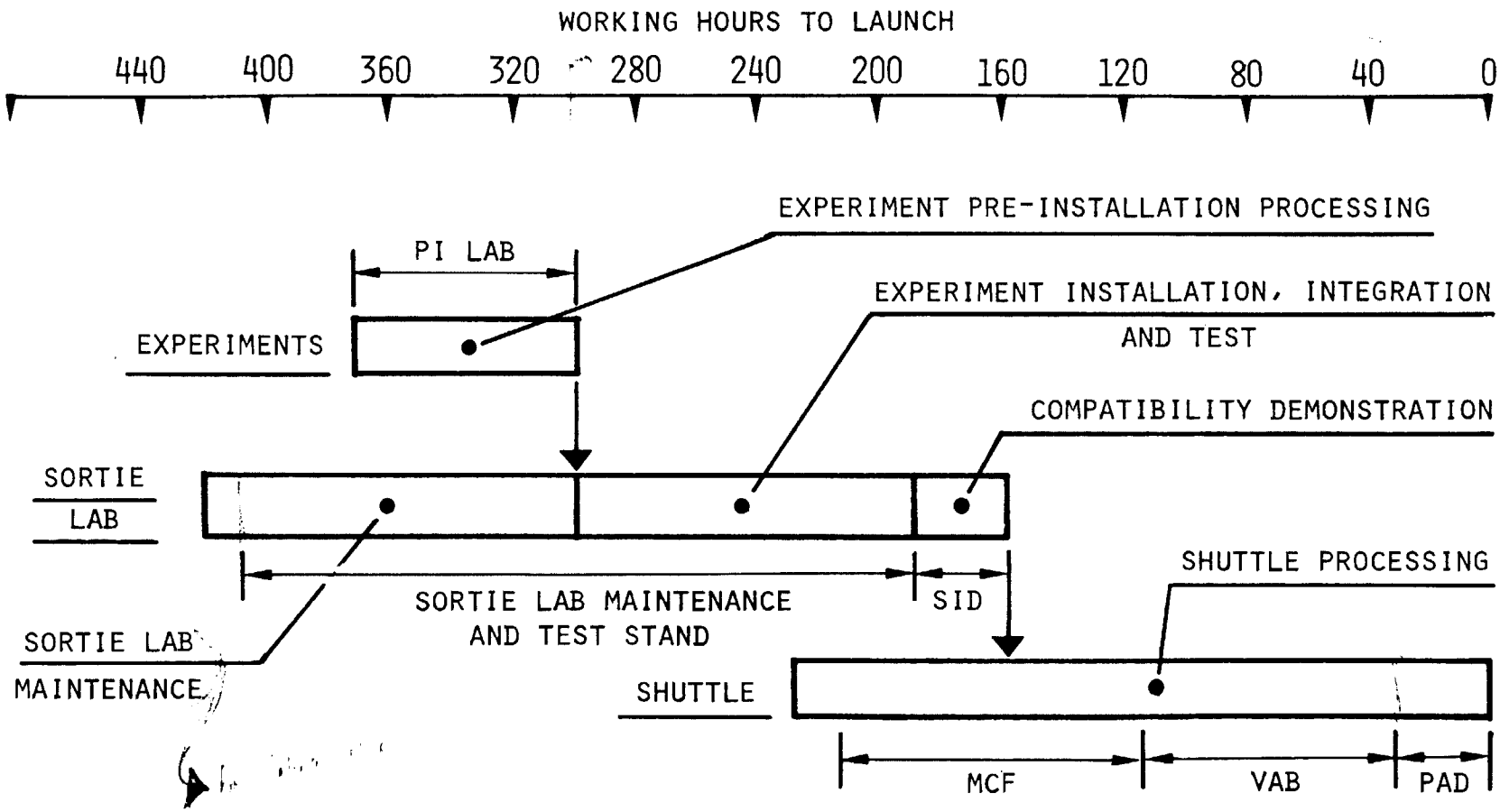
## SENSITIVITY ANALYSIS

The chart on the facing page shows the time-based functional flow diagram for the Quick-Reaction activities at the launch site. This chart is a greatly simplified version of the detailed flow diagram which is included in the Appendix volume. The primary purpose here is to show the length of time necessary to perform the ground operations. For example, the length of the Sortie Lab box on this chart when compared to the time scale at the top indicate the time required for the ground operations to the point where it is loaded into the Orbiter. This is represented by the arrow from the Sortie Lab box to the Shuttle box. This time interval is also used on the previous chart for the five Sortie Lab flights per year to establish the basic time requirements for the sensitivity analysis.

The time required for the experiment processing and the QR Sortie Lab activities is taken from the TRW ground operations analysis. The Shuttle timeline is taken from the KSC waterfall planning chart dated 4 May 1972.

# GROUND OPERATIONS

## BASELINE FLOW




TRW

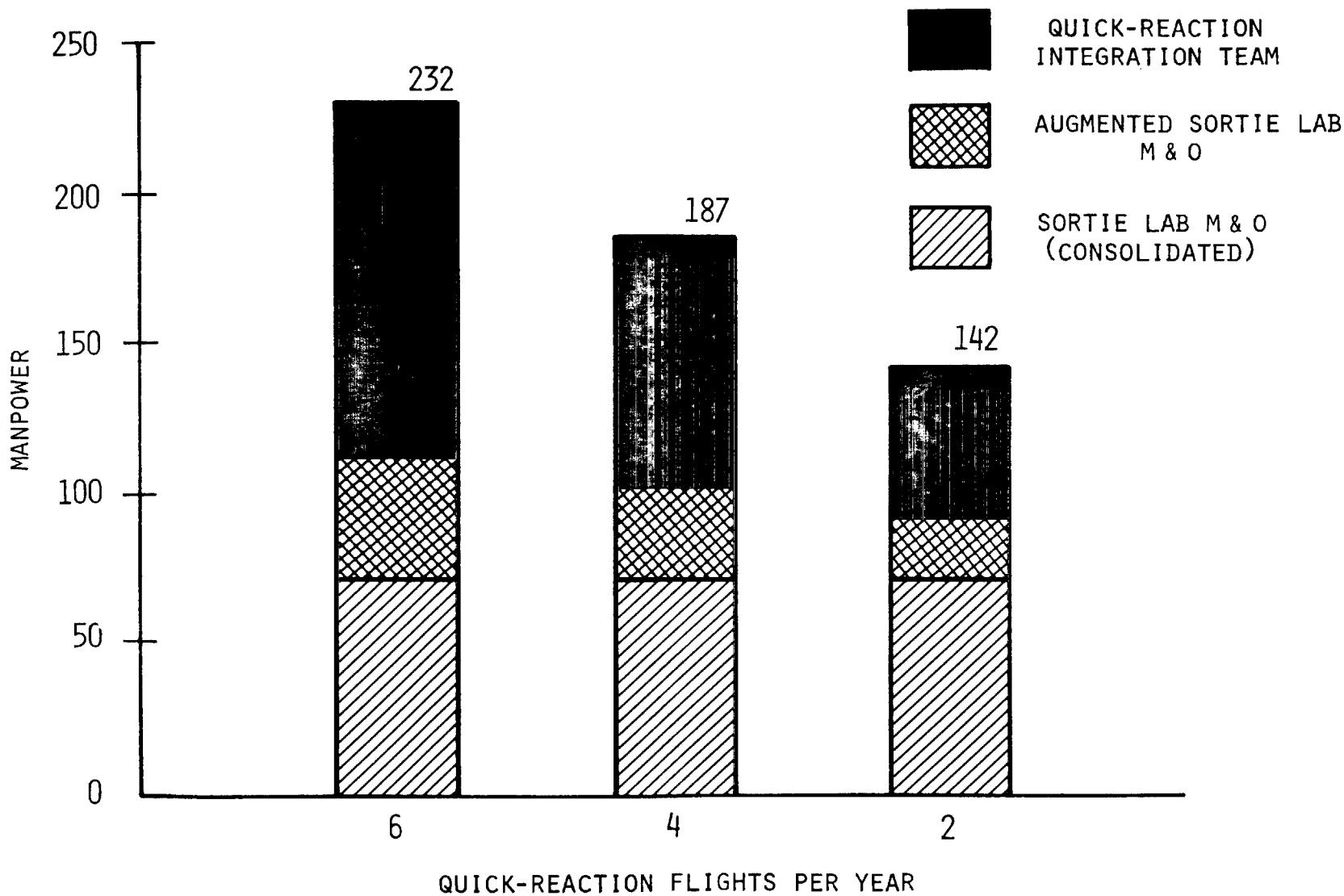
## SENSITIVITY ANALYSIS

The sensitivity analysis limited the impact on launch site facilities and equipment by assuming that five flights a year with single shift operations or seven flights a year with two shift operations (each using a single Sortie Lab vehicle) was adequate for the program. The facility and equipment requirements for these variations from the four flights a year baseline are essentially the same as for the baseline, however, manpower requirements fluctuate.

The chart on the facing page indicates the variation in manpower requirements for an increase to six QR flights per year and for a decrease to two. The Sortie Lab M&O (which is the permanent KSC Sortie Lab Operations Team) remains the same regardless of the density since they are primarily for other Sortie Lab flights. The augmented SL M&O crew consists of those additional personnel that must be provided to the KSC permanent SL Operations Team to handle the added QR flights. As shown, the number of people vary with the number of QR flights. Similarly, the manpower for the QR Integration Team varies with number of flights per year.

C-2

# SENSITIVITY ANALYSIS RESULTS




TRW

# 8.0 QR LOCATION ALTERNATIVES

## LOCATION/RESPONSIBILITY ALTERNATIVES ANALYSIS

This analysis replaces the Site Trade Study, per direction of the NASA Steering Group following the Phase 2 Progress Review.

Parameters were developed during Phase 2 and were reviewed by the Steering Group. Alternate scenarios were then developed for various modes of operation, chosen to emphasize the significant differences between alternatives. These were compared against the approved parameters, and a qualative comparison was made between alternatives.

# LOCATION / RESPONSIBILITY ALTERNATIVES ANALYSIS

OBJECTIVE:

TO INVESTIGATE THE TIME/COST PERTURBATIONS OF PERFORMING QUICK-REACTION INTEGRATION AT A REMOTE SITE (S)

APPROACH:

- ESTABLISH PARAMETERS
- DEVELOP ALTERNATE SCENARIOS
- COMPARE AGAINST RELATED PARAMETERS
- MAKE SUBJECTIVE RANKING OF ALTERNATIVES

TRW

## LOCATION/RESPONSIBILITY ALTERNATIVES

These combinations of geographical location and functional responsibility were established as the candidate alternatives by the NASA Steering Group.

In this application, the "Shuttle Operator" and "Sortie Lab Operator" refer to the organizations having responsibility for the maintenance and operation of the two items, respectively. Since both the Shuttle and Sortie Lab are assumed to be operational during this time frame, the term "Operator" is used in contrast to "Developer".

## LOCATION / RESPONSIBILITY ALTERNATIVES

| ALTERNATIVES | GEOGRAPHIC LOCATION | FUNCTIONAL RESPONSIBILITY |
|---|---|---|
| BASELINE | LAUNCH SITE | SHUTTLE OPERATOR |
| CONCEPT A | REMOTE SITE | SORTIE LAB OPERATOR |
| CONCEPT A1 | MULTIPLE REMOTE SITES | MULTIPLE SORTIE LAB OPERATORS |
| CONCEPT B | LAUNCH SITE | SORTIE LAB OPERATOR |

TRW SYSTEMS GROUP

## LOCATION/RESPONSIBILITY ALTERNATIVES ANALYSIS - PARAMETERS

The classic parameters of performance, schedule, confidence factors, and cost are used for evaluation. However, these are broken down into subheadings, each of which relates to the goals and objectives of the Quick-Reaction concept, and which considers specific attributes of the general parameter.

# LOCATION / RESPONSIBILITY ALTERNATIVES ANALYSIS

## PARAMETERS

PERFORMANCE:

- USER DESIRES, REQUIREMENTS, CONSTRAINTS
- COMPATIBILITY WITH OTHER ON-GOING PROGRAMS

SCHEDULE:

- PAYLOAD PROCESSING TIME
- CONTINGENCY RECYCLE TIME

CONFIDENCE FACTORS:

- ORBITER SCHEDULE IMPACT RISK

COSTS:

- FACILITY/EQUIPMENT UTILIZATION
- MANPOWER/SKILLS UTILIZATION
- DOCUMENTATION REQUIREMENTS
- TRANSPORTATION

TRW

## LOCATION/RESPONSIBILITY ALTERNATIVES ANALYSIS
### Assumptions and Ground Rules

These assumptions and ground rules were established to clarify and support the analysis.

Since the "Remote Sites" will probably be NASA Research or Development Centers for the most part, and due to the general phase-down of activities at all centers, it is assumed that adequate basic facilities (brick and mortar) will be available for the Quick-Reaction Integration activities.

Normal base support is assumed to be available at the remote site; e.g., motor pool, food service, communications, technical library, etc.

Since the remote sites are not identified at this time, use of specific technical capability associated with on-going programs could not be considered.

Use of the Shuttle Integration Device for pre-installation compatibility demonstration tests has been established as a requirement in this and other payload studies.

# LOCATION / RESPONSIBILITY ALTERNATIVES ANALYSIS

## ASSUMPTIONS AND GROUND RULES

- ALL POTENTIAL REMOTE QRI SITES WILL HAVE ADAQUATE FACILITIES (BRICK AND MORTAR) TO ACCOMODATE PROGRAM.
- NORMAL BASE SUPPORT WILL BE AVAILABLE AT ALL POTENTIAL REMOTE QRI SITES.
- POTENTIAL USE OF MANPOWER, SHOPS, ETC. FROM ON-GOING PROGRAMS AT THE REMOTE SITES IS NOT CONSIDERED IN THE ANALYSIS.
- THE SHUTTLE OPERATOR WILL REQUIRE THAT ALL PAYLOADS DEMONSTRATE ORBITER COMPATIBILITY IN THE SHUTTLE INTEGRATION DEVICE (SID) PRIOR TO LOADING.

TRW

## USER DESIRES

The limited user survey conducted in Phase 3 of the study showed several common desires. These are shown in order of emphasis; i.e., maximum participation and responsibility is of primary importance, while the convenience of operating from a single location is the least important.

## USER'S DESIRES

- MAXIMUM PARTICIPATION AND RESPONSIBILITY
- MINIMUM PAPERWORK
- SINGLE POINT CONTACT
- SINGLE LOCATION

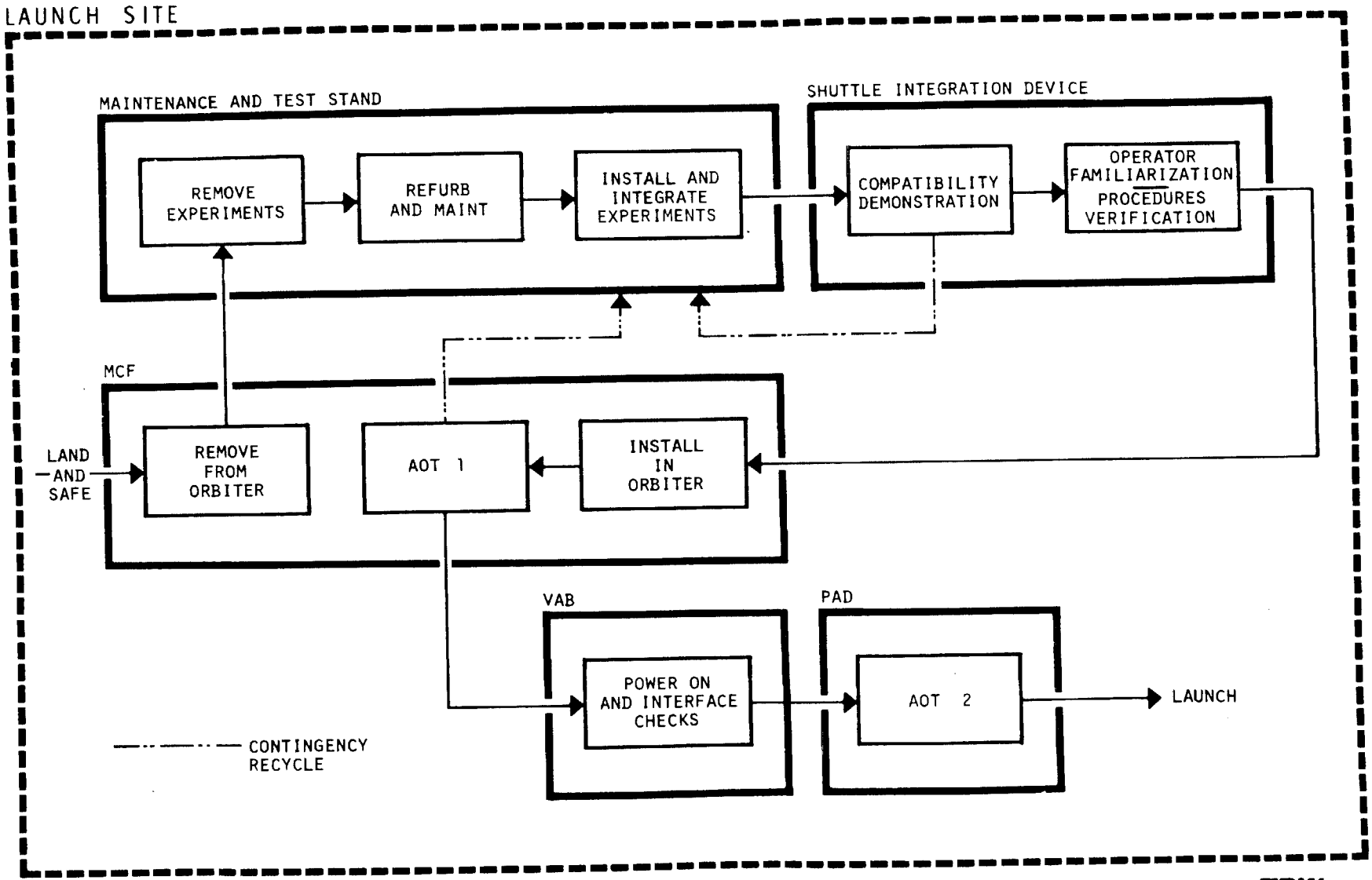
TRW
SYSTEMS GROUP

## SORTIE LAB FLOW - BASELINE CONCEPT AND ALTERNATE B

All operations occur at the Shuttle launch site in the baseline concept. Beginning with Orbiter landing and safing (center left) the flow progresses through launch (lower right). Two major contingency recycle paths are shown in dotted lines. The first, and most likely, results from failure to pass the compatibility demonstration test in the SID, with the further condition that the Sortie Lab or experiments problems cannot be corrected in the SID. The second recycle path is from the Maintenance and Checkout Facility (MCF), where the payload system fails to pass the Avionics Operational Test (AOT). It should be noted that recycle can be required from several other points on the flow - the two most probable have been shown.

# SORTIE LAB FLOW

BASELINE CONCEPT AND ALTERNATE B




TRW

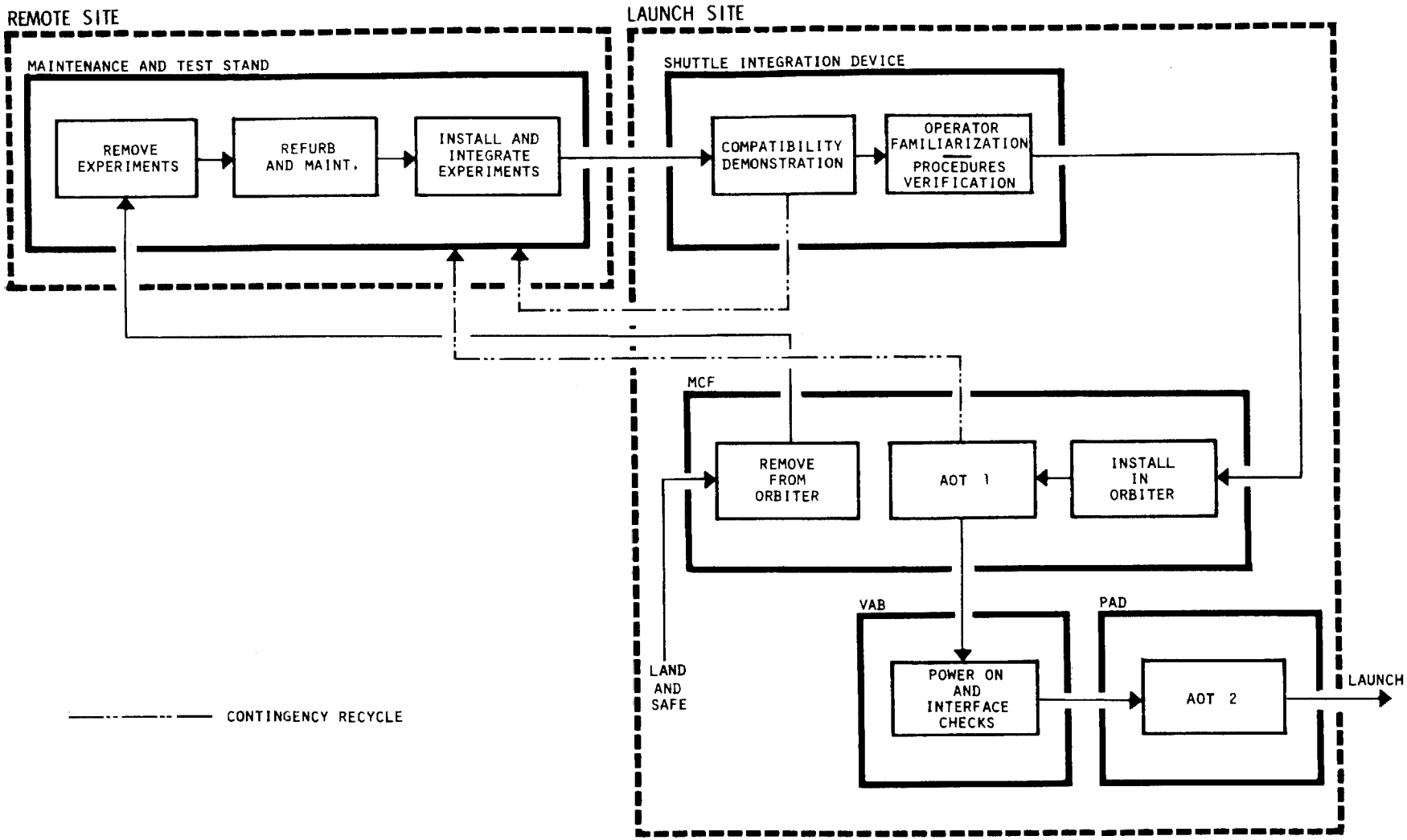
## SORTIE LAB FLOW - ALTERNATES A & A1

In this case, Sortie Lab/experiment integration is acccomplished at a remote site(s). This is the simplest case, and assumes that a completely integrated Sortie Lab shipped from a remote site has a reasonable chance of passing the compatibility demonstration test in the SID. Experience may show that a SID is also necessary at the remote site(s), resulting in duplication of relatively expensive equipment.

Both the normal and contingency recycle flows result in shipment of the Sortie Lab between the remote site and launch site. Shipping, receiving, inspection, aircraft scheduling and resulting schedule impact are factors that must be considered in this case.

# SORTIE LAB FLOW

## ALTERNATES A & A1




TRW

## PRINCIPAL PARAMETERS IMPACT - ALTERNATIVES A & A1

Payload processing time is increased by normal shipping time for the Sortie Lab, GSE and spares. After arrival at the launch site, the SL must be returned to operating condition, which will consume additional time.

A severe recycle problem is encountered if the Sortie Lab or installed experiments require Level II maintenance, which is available only at the remote site.

Orbiter schedule impact risk is increased by the uncertainties of air shipment of the equipment, i.e., aircraft scheduling, weather, etc. High contingency recycle time also affects this parameter.

Some duplication of facilities/equipment results from this mode. Minimal PI laboratories are normally furnished at the launch site even though experiments are integrated into the carrier elsewhere. It is also necessary to provide Sortie Lab M&O capability at both sites.

Transportation costs are increased over baseline by the scheduled shipment of the Sortie Lab to and from the launch site, plus the shipment of associated GSE, spares, and personnel.

# PRINCIPAL PARAMETER IMPACT

ALTERNATE A & A1

PERFORMANCE:

- USER DESIRES, REQUIREMENTS, CONSTRAINTS
- COMPATIBILITY WITH OTHER ON-GOING PROGRAMS

SCHEDULE:

- PAYLOAD PROCESSING TIME
- ➧ CONTINGENCY RECYCLE TIME

CONFIDENCE FACTORS:

- ➧ ORBITER SCHEDULE IMPACT RISK

COSTS:

- ➧ FACILITY/EQUIPMENT UTILIZATION
- MANPOWER/SKILLS UTILIZATION
- DOCUMENTATION REQUIREMENTS
- ➧ TRANSPORTATION

TRW SYSTEMS GROUP

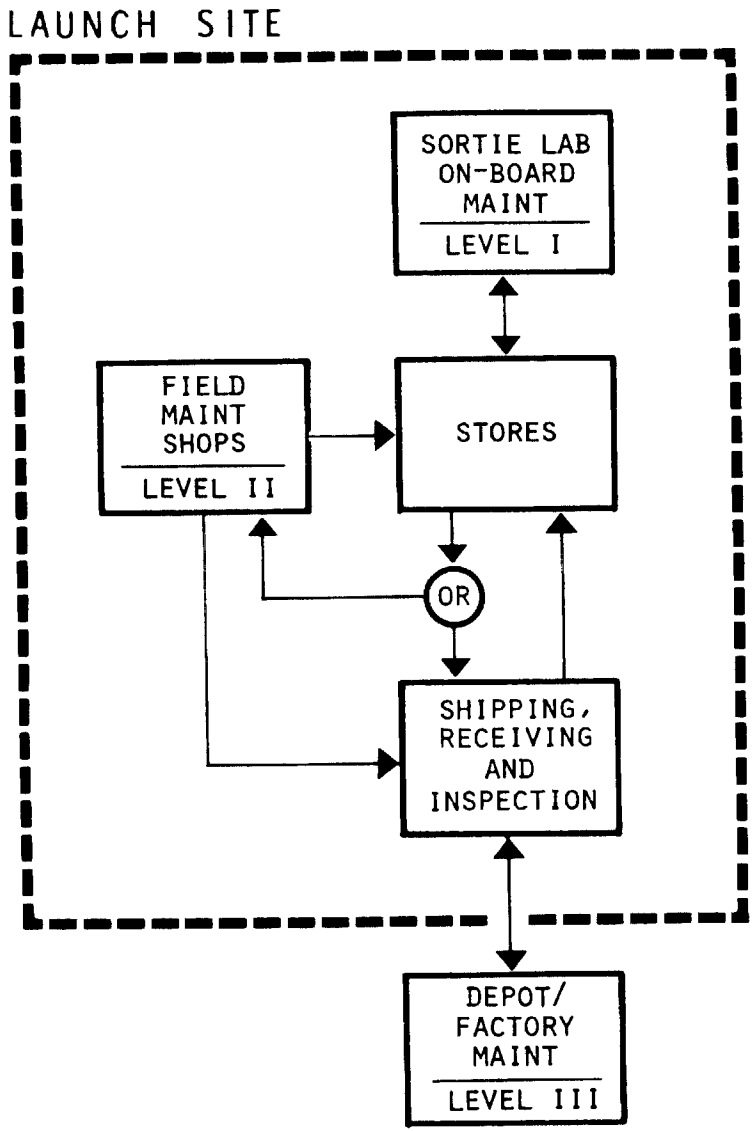
## LRU MAINTENANCE FLOW - BASELINE AND ALTERNATE B

The three levels of maintenance are depicted here. Sortie Lab subsystem or experiment Line Replaceable Units (LRU's) are removed from the Sortie Lab as a result of fault detection and isolation to an LRU. The faulty unit is normally replaced with a spare from stores and is routed to the appropriate Field Maintenance Shop (FMS) for repair. Some LRU's must be sent directly to the factory or depot for Level III maintenance. Also shown is the case where an LRU is sent to the FMS, but repair proves impossible at this level. It is then sent to the factory/depot. Repaired units are returned to stores.

The system of maintenance shown here corresponds to that planned for the Shuttle at the launch site, and is in consonance with aircraft maintenance practices.

# LRU MAINTENANCE FLOW

BASELINE CASE AND ALTERNATE B



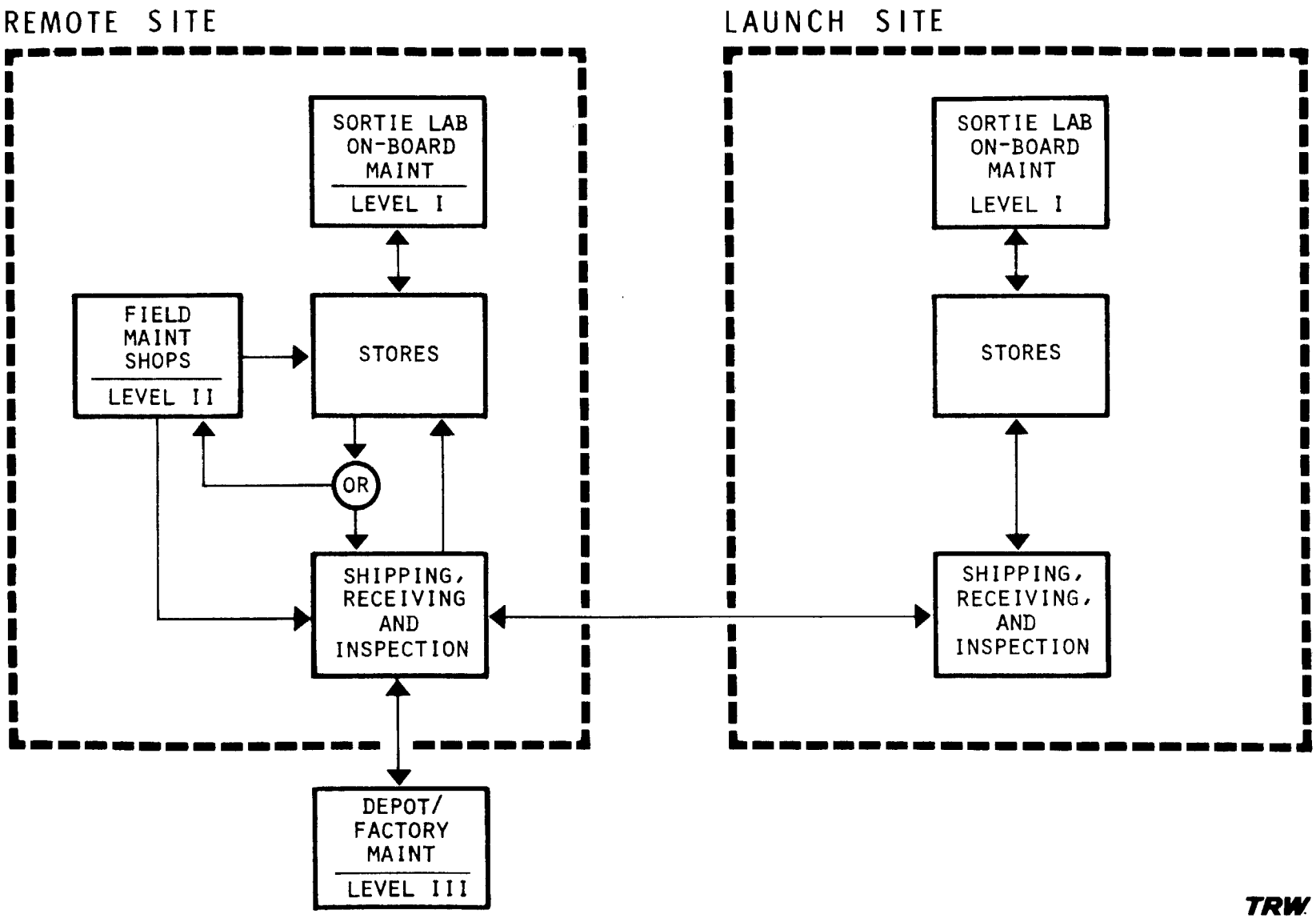

TRW

## LRU MAINTENANCE FLOW - ALTERNATES A & A1

In this scenario, the LRU maintenance system previously described for the launch site is established at the remote site, to support the integration and test activity. When the completely integrated Sortie Lab is shipped to the launch site, a minimum system must be established there for Level I maintenance. This consists of setting up a store of spare LRU's, and the necessary shipping and receiving function to support these stores from the remote site. Other systems could be devised (e.g., establishing FMS capability at the launch site), but the simplest case is chosen for comparative purposes.

# LRU MAINTENANCE FLOW

ALTERNATES A & A1




TRW

## PRINCIPAL PARAMETER IMPACT - ALTERNATES A & A1

Payload processing time may be affected by the somewhat less-than-ideal situation of having the Level II LRU maintenance activity remotely located. For example, if a spare for a particular failed LRU is not available, the unit may have to be flown to the remote site or depot/factory, and operations delayed until its return. This is particularly likely with experiment hardware, where the PI's budget may not permit adequate sparing.

Documentation is also increased by the requirement for more formal communication between the remote site and the launch site; added shipping, receiving and inspection paper; and accountability transfer that occurs at the launch site.

Transportation costs are affected by the initial transfer of spares, and maintenance of the spares pipeline. It should also be noted that additional spares procurement is required to fill the pipelines, if delays are to be prevented.

# PRINCIPAL PARAMETER IMPACT

ALTERNATE A & A1

PERFORMANCE:

- USER DESIRES, REQUIREMENTS, CONSTRAINTS
- COMPATIBILITY WITH OTHER ON-GOING PROGRAMS

SCHEDULE:

- PAYLOAD PROCESSING TIME
- CONTINGENCY RECYCLE TIME

CONFIDENCE FACTORS:

- ORBITER SCHEDULE IMPACT RISK

COSTS:

- FACILITY/EQUIPMENT UTILIZATION
- MANPOWER/SKILLS UTILIZATION
- DOCUMENTATION REQUIREMENTS
- TRANSPORTATION

TRW SYSTEMS GROUP

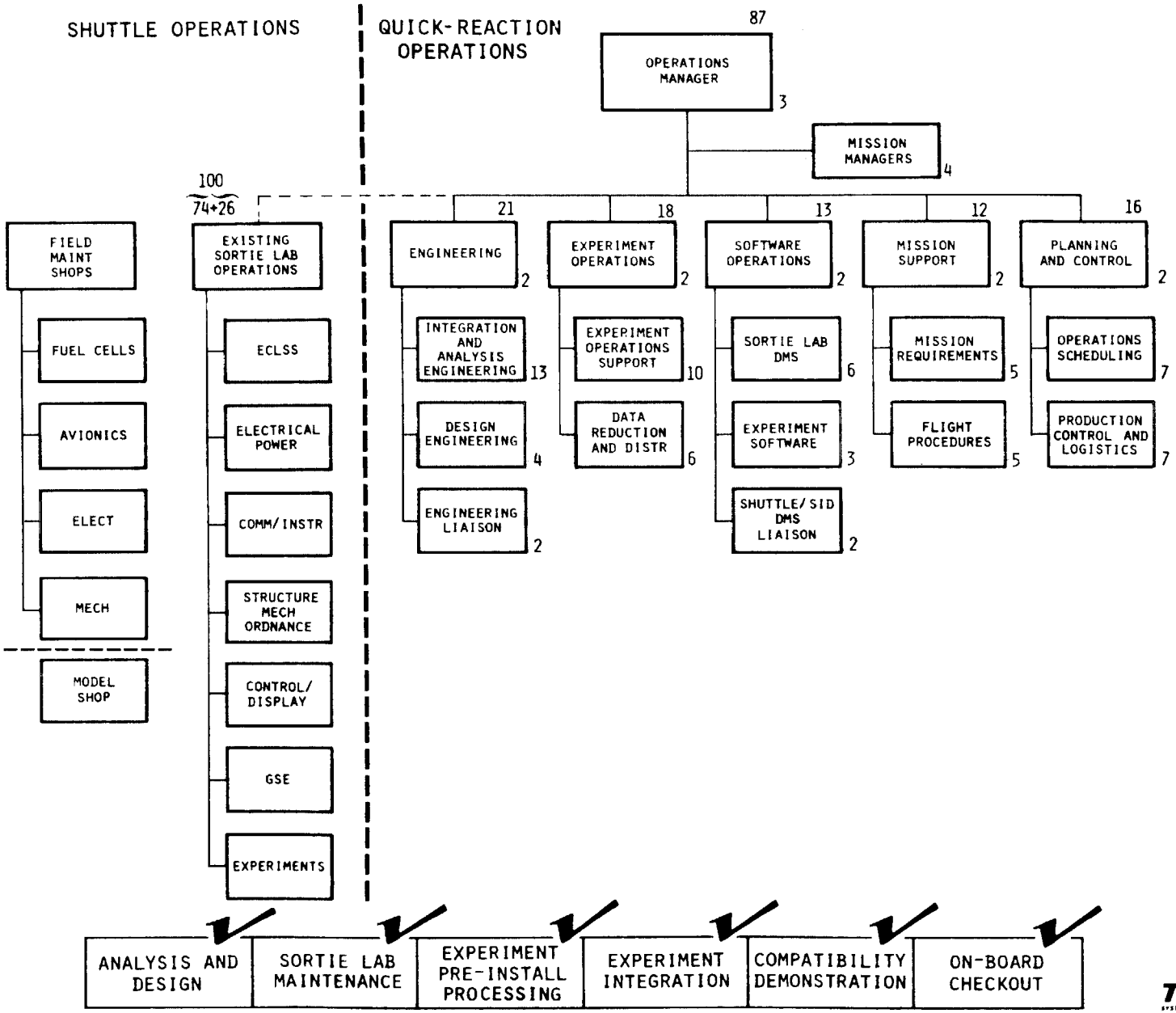
## BASELINE ORGANIZATION

In this case, the complete integration, test and prelaunch processing function is accomplished at the launch site under a single organization. Major functions performed are indicated at the bottom of the chart.

The abbreviated organization takes advantage of the planned "host" Sortie Lab crew at the launch site, which will support transient crews in the launch processing of other (not Quick-Reaction), fully integrated Sortie Labs. This 74-man crew is supplemented by 26 people to handle the additional four Quick-Reaction Sortie Lab flights per year.

Use of the Orbiter Field Maintenance Shops, and certain Shuttle management system capabilities (e.g., scheduling, configuration management) is assumed in the baseline organization. However, the supplementary equipment and manpower requirements cannot be determined at this time.

# BASELINE ORGANIZATION




TRW SYSTEMS GROUP

## SUBSYSTEM COMMONALITY

The possibility of consolidating Orbiter and Sortie Lab Field Maintenance (Level II) Shops is evident from a comparison of the respective subsystems. In aircraft maintenance, the FMS is generic in nature; e.g., in the case where several different types of aircraft are maintained at a single location, one jet engine shop supports the total operation. Subsystem/component-peculiar test equipment, tools, and technical specialists may be required to support the added workload, but an overall net saving is achieved. Consolidated Level II maintenance for Fuel Cells, Batteries, Communications Equipment, etc., represents an opportunity for substantial cost savings.

# SUBSYSTEM COMMONALITY

| ORBITER SUBSYSTEMS | SORTIE LAB SUBSYSTEMS |
|---|---|
| • MAIN PROPULSION | |
| • ORBITAL MANEUVERING | |
| • PROPELLANT SYSTEM | |
| • REACTION CONTROL | |
| • ECLSS | • ECLSS |
| • AVIONICS | |
| • STRUCTURES | • STRUCTURES |
| • THERMAL PROTECTION | |
| • APU/HYDRAULICS | |
| • GN AND C | |
| • DATA PROCESSING AND SOFTWARE | • DATA MANAGEMENT |
| • COMMUNICATIONS AND TRACKING | • COMMUNICATIONS |
| • DISPLAY AND CONTROL | • DISPLAY AND CONTROL |
| • OPERATIONAL FLIGHT INSTRUMENTATION | • OPERATIONAL INSTRUMENTATION |
| • ELECTRICAL POWER (FUEL CELLS, BATTERY) | • ELECTRICAL POWER (FUEL CELLS, BATTERY) |
| • ELECTRICAL POWER DISTRIBUTION AND CONTROL | • ELECTRICAL POWER DISTRIBUTION AND CONTROL |
| • HP GASES | • HP GASES |

TRW SYSTEMS GROUP

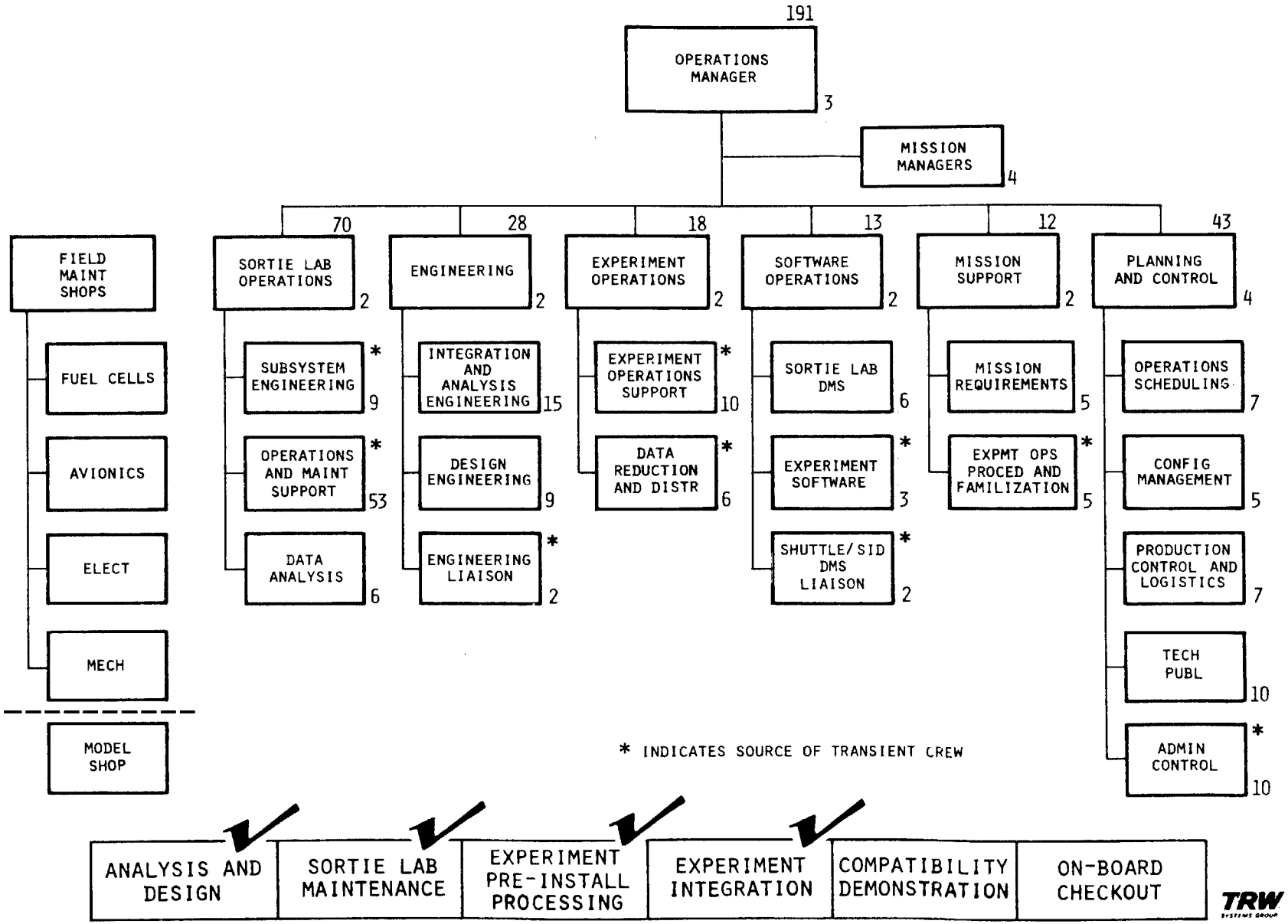
## QRI ORGANIZATION AT REMOTE SITE - ALTERNATES A & A1

This organization accomplishes the functions noted at the bottom of the chart, and delivers a completely integrated Sortie Lab to the launch site. A transient crew accompanies the Sortie Lab to the launch site, drawn from the functions as noted.

Field Maintenance Shops must be provided at the remote site. If this capability exists for other programs, consolidation of Sortie Lab Level II maintenance should be investigated. It is assumed that all candidate remote sites will have a model shop suitable for supporting the QRI effort.

# QRI ORGANIZATION AT REMOTE SITE

## ALTERNATE A

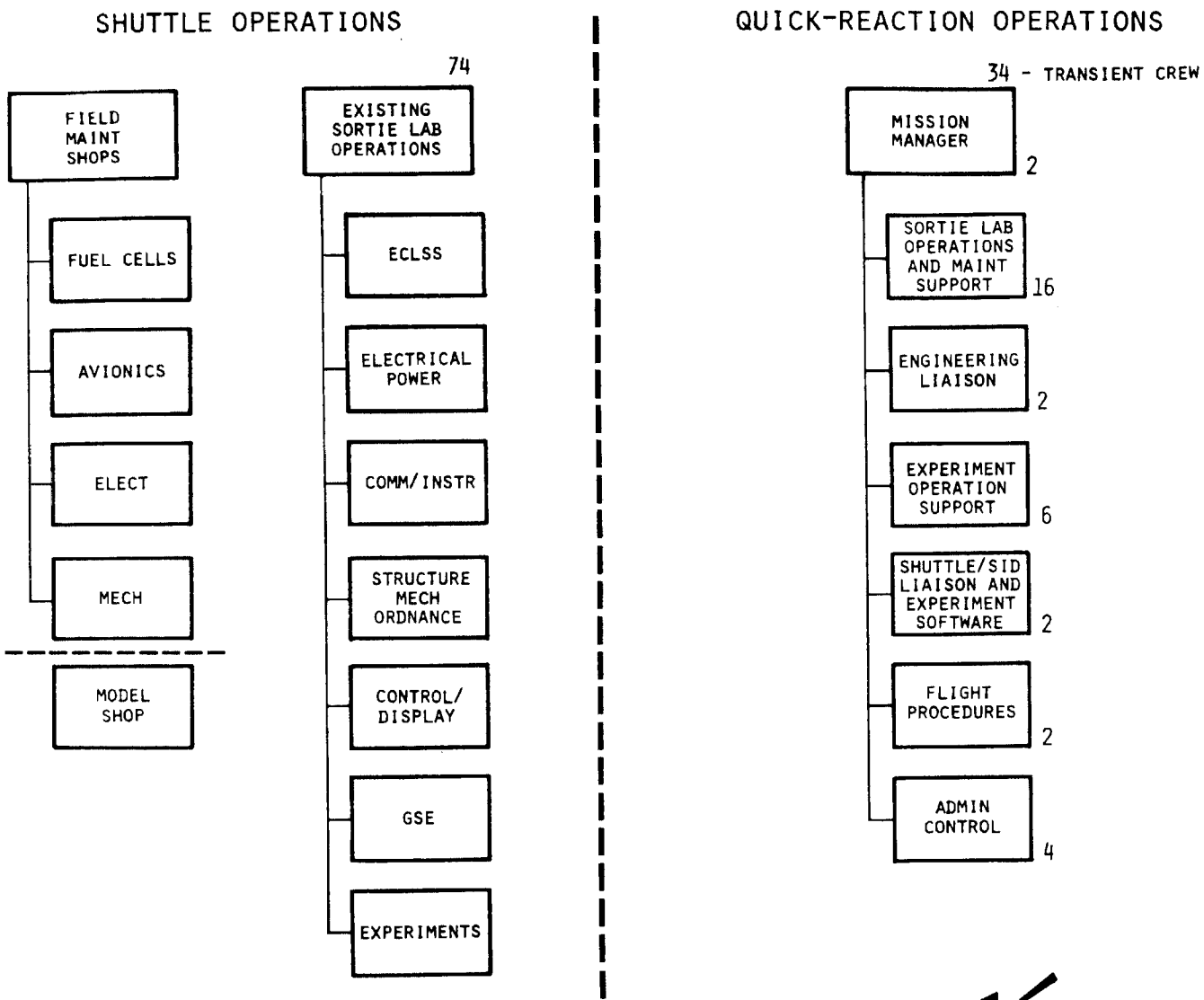


## QRI ORGANIZATION AT LAUNCH SITE - ALTERNATES A & A1

At the launch site, the fully integrated Sortie Lab must demonstrate compatibility with the Shuttle in the SID, and undergo installation into the Orbiter followed by on-board checkout. The transient crew from the remote site are responsible for maintenance and operation of the Sortie Lab and installed experiment equipment during this process, supported by the PI's. The transient crew is augmented by the resident Sortie Lab operations crew. The Shuttle Field Maintenance Shops are shown on the chart, and could provide Level II maintenance support for Sortie Lab LRU's if this were planned. In the simplest case, failed LRU's are returned to the remote site.

# QRI ORGANIZATION AT LAUNCH SITE

ALTERNATE A




| ANALYSIS AND DESIGN | SORTIE LAB MAINTENANCE | EXPERIMENT PRE-INSTALL PROCESSING | EXPERIMENT INTEGRATION | COMPATIBILITY DEMONSTRATION ✓ | ON-BOARD CHECKOUT ✓ |
|---|---|---|---|---|---|

TRW SYSTEMS GROUP

## PRINCIPAL PARAMETER IMPACT - ALTERNATES A & A1

Movement of the PI's from the remote site to the launch site imposes some inconvenience and expense. It is assumed that the PI would normally have some ground test and/or servicing equipment with him at the launch site, requiring space, logistics support, etc.

The somewhat autonomous organization at the remote site requires 191 people, compared to 113 for the baseline concept. If the Field Maintenance Shops have to be developed from scratch, this could be significantly larger.

Documentation costs are increased due to the required geographical move and organizational interface with the launch site. Transportation costs are increased by movement of personnel to and from the launch site.

# PRINCIPAL PARAMETER IMPACT

ALTERNATE A & A1

PERFORMANCE:

- USER DESIRES, REQUIREMENTS, CONSTRAINTS
- COMPATIBILITY WITH OTHER ON-GOING PROGRAMS

SCHEDULE:

- PAYLOAD PROCESSING TIME
- CONTINGENCY RECYCLE TIME

CONFIDENCE FACTORS:

- ORBITER SCHEDULE IMPACT RISK

COSTS:

- FACILITY/EQUIPMENT UTILIZATION
- MANPOWER/SKILLS UTILIZATION
- DOCUMENTATION REQUIREMENTS
- TRANSPORTATION

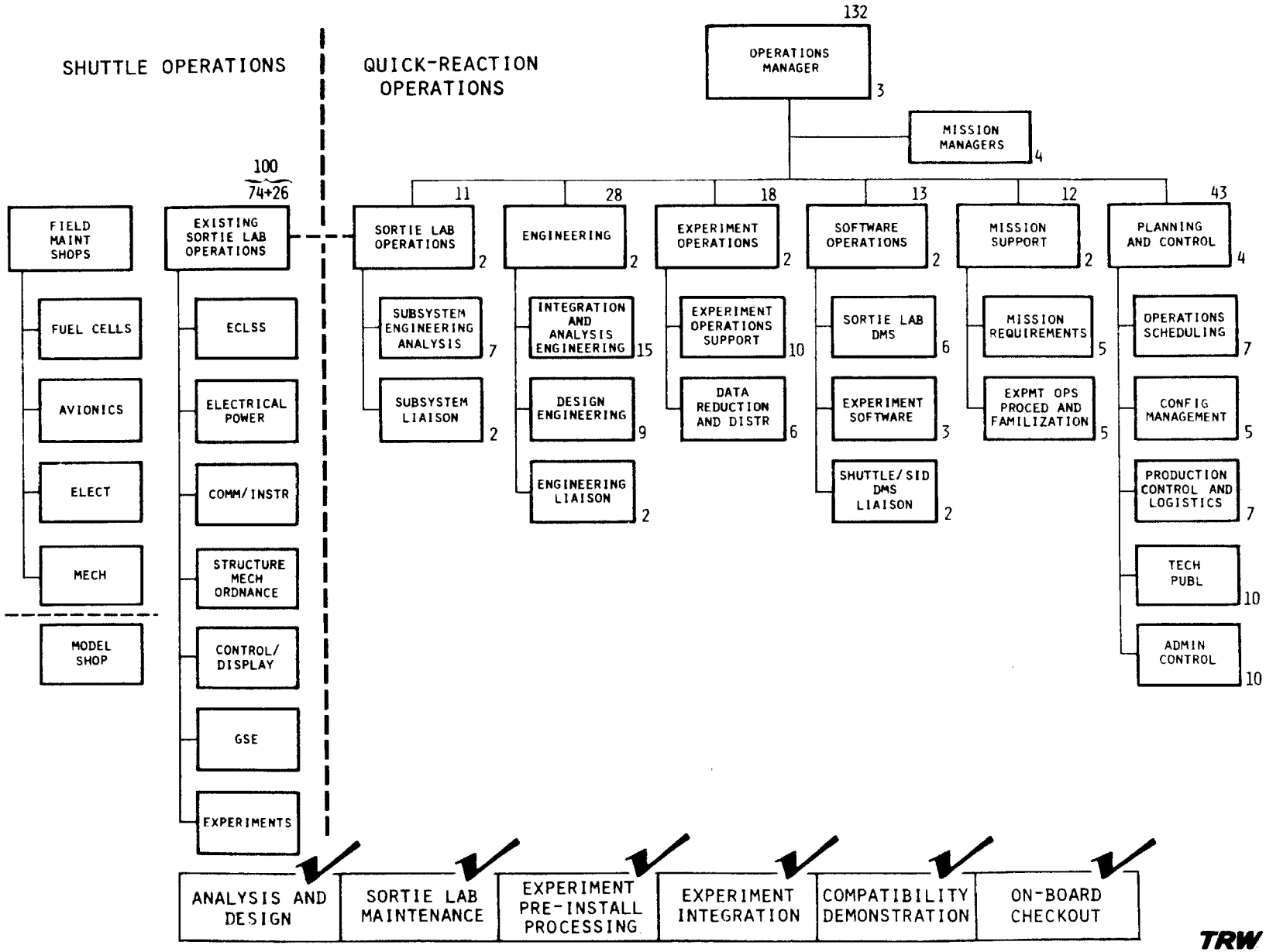
TRW SYSTEMS GROUP

## QRI ORGANIZATION - ALTERNATE B

In this mode, the integration and test of the Sortie Lab and assigned experiments is accomplished at the launch site (as in the baseline), but the activity is under the Sortie Lab Operator. This results in an organization somewhat more autonomous than the baseline, but which takes advantage of the resident Sortie Lab crew. Shuttle Field Maintenance Shops are also used in this mode, although an organizational interface is now involved in their use. Compatibility demonstration tests and on-board checkout are essentially the same as baseline.

# QRI ORGANIZATION

ALTERNATE B




TRW SYSTEMS GROUP

## PRINCIPAL PARAMETER IMPACT - ALTERNATE B

The overall efficiency and speed of payload processing will probably be affected by the existance of two organizations, and the resulting formalization of communications and accountability procedures. Manpower is also slightly increased over baseline, principally due to the need for additional advisors and liaison people at the organizational interface. In other respects, this alternative has all of the advantages of the baseline.

# PRINCIPAL PARAMETER IMPACT

ALTERNATE B

PERFORMANCE:

- USER DESIRES, REQUIREMENTS, CONSTRAINTS
- COMPATIBILITY WITH OTHER ON-GOING PROGRAMS

SCHEDULE:

- PAYLOAD PROCESSING TIME
- CONTINGENCY RECYCLE TIME

CONFIDENCE FACTORS:

- ORBITER SCHEDULE IMPACT RISK

COSTS:

- FACILITY/EQUIPMENT UTILIZATION
- MANPOWER/SKILLS UTILIZATION
- DOCUMENTATION REQUIREMENTS
- TRANSPORTATION

TRW SYSTEMS GROUP

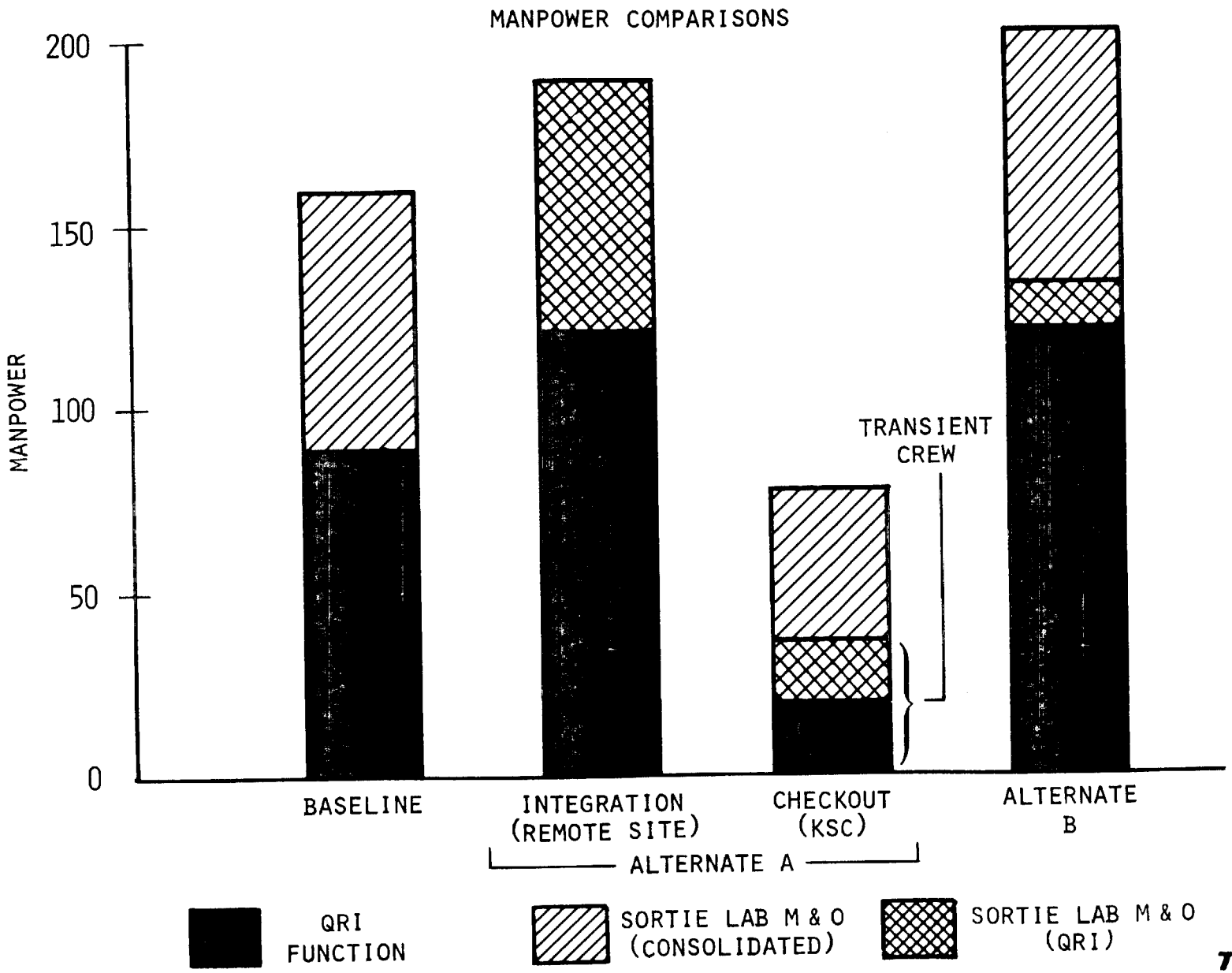
## LOCATION/RESPONSIBILITY ALTERNATIVES ANALYSIS - MANPOWER COMPARISONS

The manpower totals for the two basic alternatives are compared to the baseline in this chart. In order to make this comparison on an equal basis, it has been assumed that the equivalent full-time personnel used from the "host" Sortie Lab crew at the launch site is 44 (from a total of 74). This, plus the 26 additional people assigned to the crew to accommodate the QRI workload, gives a total Sortie Lab crew of 70.

It should be noted that the total manpower for Alternate A rises to 232 during the launch site phase; i.e., transient crew of 34 supplemented by 41 resident Sortie Lab people, plus the 157 remaining behind at the remote site.

Alternate A1 is not shown, but clearly represents the least efficient use of manpower of the alternatives considered, in that the increased manpower over baseline of Alternate A is multiplied by the number of remote sites.

# LOCATION / RESPONSIBILITY ALTERNATIVES ANALYSIS




TRW

## COMPARISON OF ALTERNATIVES

The various alternatives are compared to the baseline, considering the established evaluation parameters. The parameters have been restated as desirable objectives or goals, and the various alternatives are rated as high (H), medium (M), or low (L) as to their effectiveness in attaining this goal.

In two cases, it was not possible to evaluate Alternates A and A1, since the remote sites have not been designated, making comparisons relative to ongoing programs and available manpower/skills impossible.

The parameters have not been weighted, so that a quantitative comparison is not possible. It is evident, however, that the single location, single organization of the baseline concept is very attractive for the Quick-Reaction concept. Alternate B also appears attractive, but introduces some duplication and formality that is avoided in the baseline.

This qualitative analysis may be useful in the development of payload processing concepts. As the Shuttle Program matures, quantitative site selection trade studies should be performed to support final decisions.

# COMPARISON OF ALTERNATIVES

| CONCEPT | BASELINE | A | A 1 | B |
|---|---|---|---|---|
| GEOGRAPHIC LOCATION | LAUNCH SITE | REMOTE SITE | MULTIPLE REMOTE SITE | LAUNCH SITE |
| FUNCTIONAL RESPONSIBILITY | SHUTTLE OPERATOR | SORTIE LAB OPERATOR | SORTIE LAB OPERATORS | SORTIE LAB OPERATOR |
| MEETS USER DESIRES, REQUIREMENTS, CONSTRAINTS | H | M | M | H |
| IS COMPATIBLE WITH ON-GOING PROGRAMS | M | - | - | M |
| MINIMUM PAYLOAD PROCESSING TIME | H | L | L | M |
| MINIMUM CONTINGENCY RECYCLE TIME | H | L | L | H |
| MINIMUM ORBITER SCHEDULE IMPACT RISK | H | L | L | H |
| MOST EFFECTIVE EQUIPMENT/FACILITY USE | H | M | L | H |
| MOST EFFECTIVE MANPOWER/SKILLS USE | H | - | - | M |
| MINIMUM DOCUMENTATION | H | L | L | M |
| MINIMUM TRANSPORTATION COST/TIME | H | L | L | H |

TRW

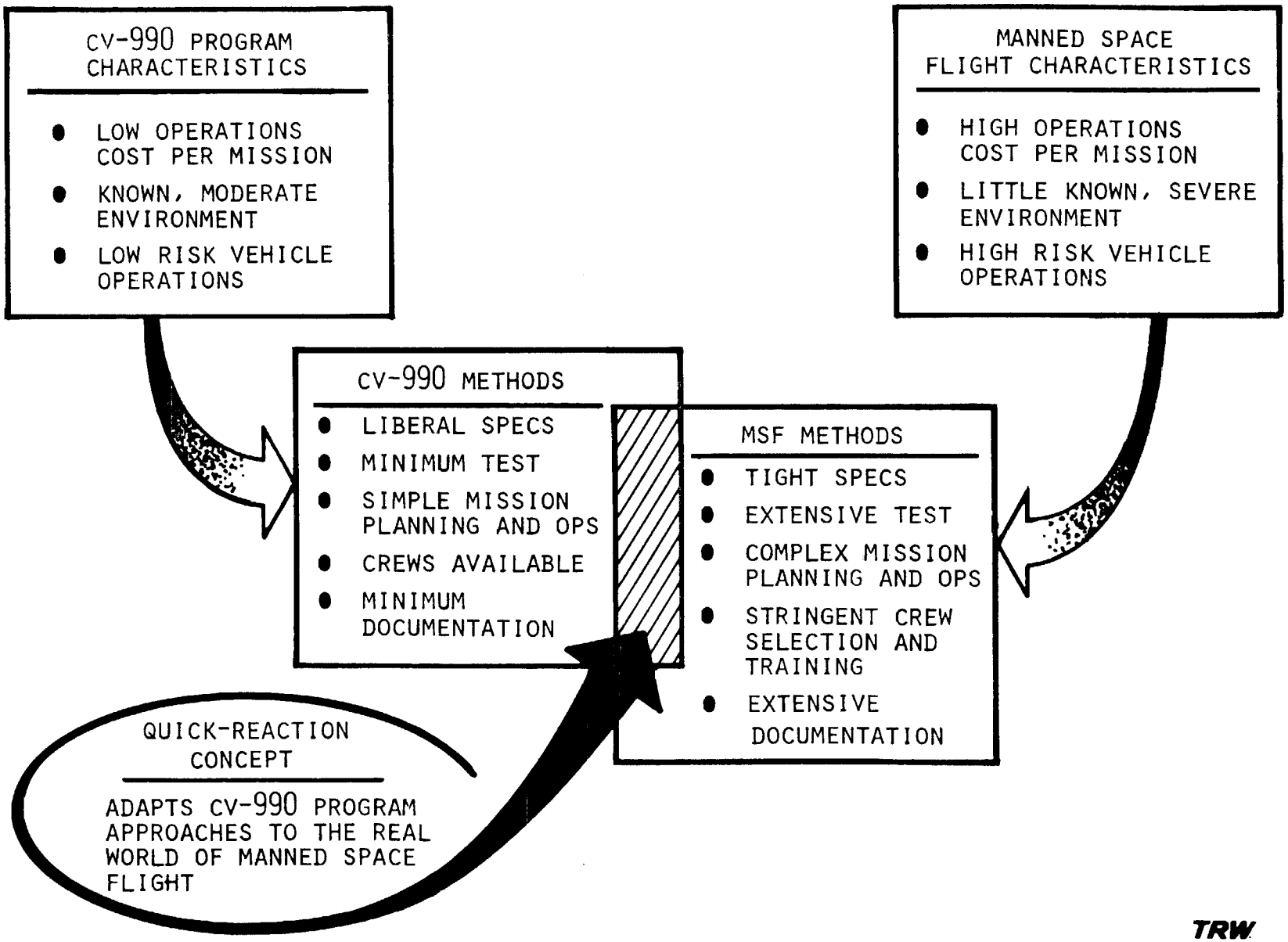
# 9.0 SUMMARY

## QUICK-REACTION CONCEPT

In retrospect, this study has developed an operational concept or model by taking the user-oriented approaches of the CV-990 Airborne Science Program developed by Ames and testing them in the manned space flight environment as visualized for the Space Shuttle era.

The capabilities of the Space Shuttle and the planned user-oriented philosophy have made the application of the CV-990 Program approaches applicable to a high degree. However, as constraints imposed by manned space flight were considered, the resulting model became considerably more complex than the aircraft program. Given the Sortie Lab as a carrier, however, the model as developed represents a minimum complexity/cost baseline, against which other concepts and approaches may be compared.

# QUICK REACTION CONCEPT




TRW

## PRINCIPAL FEATURES OF QR CONCEPT

The QR Integration Team of artisans and craftsmen provide an outstanding service to the user community, supplying a wide variety of skills to quickly adapt the user's equipment to the Sortie Lab. The R&D atmosphere prevalent in this group allows inovation to be the rule rather than the exception.

The building block approach to software integration allows the user to integrate his software with the flight and ground systems, while he is developing it in his home lab.

A greatly simplified approach to the mission planning function was developed. Although simple, the approach recognizes the mandatory functions involved in mission planning and flight operations, and provides a realistic interface with that activity.

The concept also makes use of other identified on-going capabilities at the launch site; i.e., maintenance and operation of other Sortie Labs and Orbiter turnaround support.

## PRINCIPAL FEATURES OF QR CONCEPT

- HARDWARE INTEGRATION APPROACH PROVIDES FLEXIBILITY - "WE CAN FLY YOUR EXPERIMENT"
- BUILDING BLOCK APPROACH TO SOFTWARE INTEGRATION
- REALISTIC, SIMPLIFIED INTERFACE WITH MISSION PLANNING - FLIGHT OPERATIONS WORLD
- EFFICIENT UTILIZATION OF RESOURCES WITH:
  - ARTISAN APPROACH
  - PLANNED SORTIE LAB OPERATIONS
  - SHUTTLE FIELD MAINTENANCE SHOPS

TRW

## AGENCY CONSIDERATIONS

The baseline experiments were specifically selected to allow integration at the launch site. However, viewed against the experiment spectrum definable in 1973, the baseline experiments covered a significant part.

Current agency goals for design of experiment hardware and support subsystems tend to simplify the integration task. Therefore, in the 1980's the Quick-Reaction concept for integrating experiments into the Sortie Lab could be a large part of the Sortie payload activity.

# AGENCY CONSIDERATION

- THE QUICK-REACTION OPERATIONAL CONCEPT WILL ACCOMODATE A SIGNIFICANT SEGMENT OF THE EXPERIMENT HARDWARE SPECTRUM VISIBLE IN 1973
- THE OBSERVABLE TRENDS AND GOALS FOR PAYLOAD SYSTEM DESIGN ARE:
  - STANDARD INTERFACES
  - MODULAR HARDWARE & SOFTWARE
  - STANDARD SUPPORT SUBSYSTEMS
  - "OPERATIONAL" SENSORS.
- IT FOLLOWS THAT PAYLOAD SYSTEMS OF THE 1980's WILL BE MORE, NOT LESS, COMPATIBLE WITH THE QUICK REACTION OPERATIONAL CONCEPT.

TRW