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MARTIN MARIETTA

POST OFFICE BOX 179, DENVER, COLORADO 80201

PAYLOAD CREW ACTIVITY PLANNING INTEGRATION

TASK 2

CONTRACT NAS9-14676

INFLIGHT OPERATIONS AND TRAINING FOR PAYLOADS

DECEMBER 23, 1976

Submitted by: _____

F. R. Hitz, Task Manager
Martin Marietta Aerospace - Houston Operations

Approved by: _____

D. L. Purdum, Program Manager
Martin Marietta Aerospace - Houston Operations

FOREWORD

This document has been prepared by the Denver Division - Houston Operations of Martin Marietta Aerospace for the National Aeronautics and Space Administration, Johnson Space Center. It is submitted in fulfillment of DRL line item 4 of Contract NAS9-14676 and constitutes the final report for Task 2 - Payload Crew Activity Planning Integration - of the Inflight Operations and Training for Payloads Study. All inquiries and comments should be submitted to:

Mr. William M. Anderson
Mail Code CG 5
Lyndon B. Johnson Space Center
Houston, Texas 77058

ACRONYMS/ABBREVIATIONS

ACQ	-	Acquisition
ACT	-	Activate or Activation
ADJ	-	Adjust
AFD	-	Aft Flight Deck
ATL	-	Advanced Technology Lab
ATT	-	Attitude
BOP	-	Baseline Operations Plan
CAP	-	Crew Activity Plan, Crew Activity Planning
CAT	-	Category
C&D	-	Control and Display
C&W	-	Caution and Warning
CCTV	-	Closed Circuit Television
CDR	-	Commander
C/O	-	Checkout
CRT	-	Cathode Ray Tube
DEC	-	Declination
DEG	-	Degree
DRL	-	Document Requirements List
DUST	-	Deep Sky UV Survey Telescope
ESA	-	European Space Agency
EXP	-	Experiment
FUS	-	Far UV Spectrograph
FWD	-	Forward
GMT	-	Greenwich Mean Time
GPC	-	General Purpose Computer
HO	-	Handover
HR	-	Hour
I	-	Inclination
IMU	-	Inertial Measurement Unit
INCRE	-	Increment
INSTR	-	Instrument
I/O	-	Input/Output
IP	-	Implementation Plan
IPS	-	Instrument Pointing System
IRU	-	Inertial Reference Unit
IUS	-	Interim Upper Stage
KB	-	Keyboard
MCC	-	Mission Control Center
MET	-	Mission Elapsed Time
MGT	-	Management

MIN	-	Minute
MMC	-	Martin Marietta Corporation
MNVR	-	Maneuver
MOCC	-	Mission Operations Control Center
MPM	-	Minipointing Mount
MS	-	Mission Specialist
MUX	-	Multiplex
NMI	-	Nautical Mile
OFT	-	Orbital Flight Test
OOS	-	Onorbit Station
OPS	-	Operations
ORB	-	Orbiter
PDC	-	Payload Development Center
PDR	-	Preliminary Design Review
PET	-	Phase Elapsed Time
P/L	-	Payload
PLT	-	Pilot
POCC	-	Payload Operations Control Center
POS	-	Position
PS	-	Payload Specialist
PTG	-	Pointing
PWR	-	Power
RA	-	Right Ascencion
REV	-	Revolution
RID	-	Review Item Discrepancy
RMS	-	Remote Manipulator System
RT	-	Right
RTOP	-	Research and Technology Objectives and Plans
SEC	-	Second
SEQ	-	Sequence
SIG	-	Signal
S/L	-	Spacelab
SMS	-	Spacelab Mission Simulator
S/R	-	Sunrise
S/S	-	Sunset
STDBY	-	Standby
STS	-	Space Transportation System
SUOT	-	Spacelab UV Optical Telescope
SUSS	-	Shuttle UV Stellar Spectrograph
SYS	-	System
TARG	-	Target
TBD	-	To Be Determined
TDRS	-	Tracking and Data Relay Satellite
TEL	-	Telescope
TV	-	Television

UT	-	Universal Time
UV	-	Ultraviolet
VCU	-	Video Control Unit
XLATE	-	Translate
Z	-	Zenith

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FIGURES AND TABLES

1.0 INTRODUCTION AND STUDY OBJECTIVES

The following Final Report presents a synopsis of the activities for Payload Crew Activity Planning Integration (Task 2) of the Inflight Operations and Training for Payloads contract. The task was initiated in July, 1975 with the purpose of developing methods for Crew Activity Planning Integration in the Shuttle Operations timeframe. The study was to be performed in such a manner as to allow the Payload Centers to participate as much as desired. Each center had an assigned interface for the study and was contacted initially with background data, a full explanation of the intent, and an open invitation to participate in the team development of crew activity planning methodology for the Space Shuttle Program.

The primary objectives of the Payload Crew Activity Planning Integration task were to:

- o Determine feasible, cost-effective payload crew activity planning integration methods.
- o Develop an implementation plan and guidelines for payload crew activity plan (CAP) integration between the JSC Orbiter planners and the Payload Centers.

Subtask objectives and study activities were defined as:

- o Determine Crew Activity Planning Interfaces.
- o Determine Crew Activity Plan Type and Content.
- o Evaluate Automated Scheduling Tools.
- o Develop a draft Implementation Plan for Crew Activity Planning Integration.

The basic guidelines were to develop a plan applicable to the Shuttle operations timeframe, utilize existing center resources and expertise as much as possible, and minimize unnecessary data exchange that is not directly productive in the development of the end-product timelines.

More specific assumptions and groundrules are specified in Section 3.1.2 of the Draft CAP Implementation Plan (Section 3.0) and are therefore not duplicated here.

2.0 SUMMARY OF STUDY ACTIVITIES

The primary objectives and subtask objectives were met as identified in this final report. The study of payloads, identification of interfaces, evaluation of automated scheduling tools and definition of CAP integration data were the prime task study activities which resulted in the design of Crew Activity Plan types, content and formats, and the STS CAP Integration Implementation Plan.

The task was initiated with Payload Center visits and requests for CAP Center information and program status. The request for information was initially in the form of a written set of questions which met with mixed response from the Centers.

The Payload Centers and contacts identified for study interface were:

MSFC	(H. Waters)
GSFC	(S. J. Osler)
LaRC	(C. P. Llewellyn)
ARC	(Dr. R. Johnson)
JPL	(P. Barnett)
JSC	(G. McCollum and R. Wilmarth)

The written set of questions were followed by telecons and visits with the Centers. The initial responses (September - November 1975) were primarily that the center was pursuing some activity related to crew activity planning or that it had not yet addressed the activity so early in the Shuttle timeframe. Some Centers had not totally identified the Payload Center organization, in particular the crew activity planning involvement. All Centers showed significant expertise in operations, scheduling, sequence planning and generation either applicable to unmanned or manned spacecraft. MSFC and LaRC both

have highly developed crew activity planning operations and supporting software. Sophisticated planning software was identified at JPL and GSFC, which offered highly automated scheduling techniques for consideration to Shuttle Payload flight and crew activity planning functions.

The initial introductory task activities were primarily designed for orientation of the study, rather than to evaluate Payload Center crew activity planning. The visits did, however, provide a good baseline of Center CAP activity status.

In order to pursue the primary objectives of the study, it was necessary to first gather and review various proposed payloads for the identification of Payload types, design, operation and interfaces (with the Orbiter) relative to the problem of Crew Activity Planning.

A list of the Payloads reviewed is included in Section 3.8. These reviews and evaluations of Payloads and the available Center Crew Activity Planning or related documentation provided the primary requirements and data for the identification of CAP data elements and CAP forms design (see Section 3.3 and 3.6 of the Integration Implementation Plan).

The Shuttle payload accommodations and the general flight design characteristics of the various potential missions were also reviewed to understand the relationships/interfaces between the Orbiter, mission characteristics, and the payload operations and to add to the identification of the prime CAP influencing factors.

A process to integrate the crew activities, Orbiter systems requirements and payload operations was developed from the requirements identified in the above evaluations and the current Payload Center thinking on CAP development processes. The primary sources for evaluation of time-phased CAP development, planning and flow processes were MSFC and JSC.

In addition, other associated CAP material was reviewed and evaluated for Crew Activity Planning influence, such as the following software and software requirements.

FAST - Fast Automated Scheduling Technique (MSFC - existing);
MIPS - Marshall Interactive Planning System (MSFC - currently being developed);
MASS - Manned Activity Scheduling System (Langley - existing);
LSEQ - Viking Lander Sequence of Events Scheduler (JPL - existing);
LCMSM - Viking Lander Command Sequence Predictor (JPL - existing);
CAP Planning - Software - Ops Timeframe (JSC - currently being developed).
Demonstration of existing software for unmanned spacecraft operations at GSFC.

The conclusions and recommendations of the study are contained in Sections 2.1 and 2.2 of this report, with the primary product of the reviews, evaluations, and development activities of the study contained in Section 3.0 - Draft CAP Integration Implementation Plan.

Section 3.0 is the recommended CAP (Crew Activity Plan) Integration Implementation Plan to be used to integrate all on-orbit crew activity operations. The CAP Integration Implementation Plan is a stand-alone document that may be separated from this final report for Center use.

It should be noted that the plan contains specific Shuttle CAP concepts and discussions of these concepts developed from the study. It also contains specific data element lists which include the interfaces and CAP data items for exchange between the STS Operator and the Payload Centers. Shuttle era forms for CAP integration have been designed and are included.

2.1 CONCLUSIONS

1.) Operational Differences Between Shuttle and Past Programs

The study found that a diversity of operations exists for the Shuttle Program flights. Spacelab Module flight operations have the most similarity to Skylab mission activities, but with added sophistication in many tasks, equipment and interfaces. It is to this type of mission that Skylab crew activity planning experience relates best.

Freeflyer and planetary missions represent the other end of the spectrum - that most akin to the Apollo format time sequenced trajectory events that require a minimum number of iterative interfaces with ground based planners.

All types of flights contain a significant amount of automation compared to past scientific on-orbit operations. Flights which are dependent on the orbital geometry in reference to observation opportunities have a very similar Crew Activity Planning problem to Skylab. These high activity, on-orbit flights are still the most complex to plan, integrate and update in real-time.

A variety of operational differences which affect crew activity planning and scheduling were identified:

a) Related functions of preparation, equipment physical setup, installation, stow, etc. have been reduced, primarily in the pallet oriented operations. This leaves more time for the operations functions and potential on-orbit evaluations and activities.

b) The mode of operation for a great number of payload functions is projected for a combination of discrete controls and displays and multidisciplined keyboard/CRT operations, in comparison to the unique dedicated C&Ds utilized on previous spacecraft.

c) The operation of a large majority of payload functions is controlled by a centralized shared computer. Skylab, in comparison, primarily contained independently functioning hardware without a centralized shared control system.

d) A major mode of on-orbit manned operations has been added in Shuttle - remote manipulation and the related dynamic conditions while operating. For crew activity planning, this operation is significant if considerable crew interaction requiring scheduling during operation is required.

e) A potential frequently used on-orbit interface is the ground remote operation of some payloads and instruments. Past manned spaceflights did not frequently use the capability of ground control and operation of onboard experiments, although the capability existed in many cases. This dual control philosophy can bring about scheduling interface problems.

f) On-orbit operations will have more flexibility in Shuttle than in past programs. This will allow additional options in operating experiments and in-flight optimization is more feasible when effected by ground or onboard activity rescheduling. This could increase the complexity of CAP planning and timelining.

2.) CAP Flow

Crew Activity Plan (CAP) integration for all missions can be very similar to the basic operational flight plan preparation method used for long duration missions. This method started with experiment discipline inputs submitted to a flight planner who developed a summary plan, which was then reviewed by the scientific disciplines and mission operations resources, then finalized by the flight planner. The flight planner had all the tools, forms and scheduling criteria which were the guidelines and groundrules for the summary flight plan development.

Shuttle CAP integration can operate similarly with the Payload Centers inputing to the STS Operator, the STS Operator developing the initial summary STS Crew and Orbiter CAP, submitting it to the Payload Centers for review and full detailed Payload CAP development. The Payload Center then forwards the integration aspects of the Payload operation for final integration by the STS Operator.

This type of integration is, however, only one potential type of integration flow discussed in the Draft CAP Integration Implementation Plan.

A major difference in the Shuttle integration is that the payload operation detailed planning is done by the Payload Center and only the integration aspects of that plan need be forwarded to the STS Operator. The forms and scheduling criteria required for payload operations are not required by the STS Operator unless the STS Operator is performing the scheduling for that particular payload. The forms and scheduling criteria of the Crew and Orbiter Overhead for integration will be used by both the Payload Center and the STS Operator.

3.) Review of CAP Software

One major crew activity planning software technique currently in the development phase is the MSFC Marshall Interactive Planning System (MIPS). This system should contain extensive capabilities for crew activity and systems/equipment/experiment scheduling when fully developed.

The MIPS is potentially a powerful tool and should be assessed, as developed, by each of the centers who would be involved in crew activity and/or interactive on-orbit event scheduling.

A significant aspect of the MIPS is the real-time interactive planning capability, allowing initial preflight planning as well as a quick reaction to changes. The MIPS is a comprehensive tool involving flight design characteristics in addition to crew scheduling. Its applicability to all payload flights still needs review after completion.

The LaRC Manned Activity Scheduling System is another automated scheduling system. This system has proven successful for premission as well as real-time planning. As currently utilized, its primary strength lies in the data organization capabilities for activity scheduling data/criteria.

JSC is currently developing scheduling software but has none operational for Shuttle applications at present. Both JPL and GSFC have

extensive sequencing and resource management software than can be applied to the crew activity planning tasks as necessary.

Numerous questions should be resolved before additional complex CAP scheduling software is developed. Among these questions are those relating to emphasis on retaining the premission plan on-orbit versus significant real-time replanning.

As mentioned earlier, significant experience with various planning scheduling and sequence development software is available and a combination of these tools, the "total system" as given by MIPS and segmented CAP planning aids, is likely to be the answer to the total software needs for CAP.

A recommendation of CAP software development priorities is given in Recommendation 7.

4.) Different Levels of CAP Participation

All Payload Centers are not likely to participate at the same level or in the same way relative to Crew Activity Plan development and integration.

The divisions of flight activity and mission responsibilities give a difference in the degree of involvement in Crew and Orbiter interaction. In the case of freeflyers and planetary missions, the involvement is much less than it is for Spacelab missions.

The amount of time (i.e., during on-orbit) that the freeflyers and planetary Shuttle flight Payloads are interactive with the Orbiter is much less than a Spacelab Payload and the emphasis is upon a single time point on-orbit (i.e. delivery of freeflyer or IUS ignition).

It is therefore recognizable that less Payload Center interaction and coordination for CAP integration is to be expected when free-flyer and planetary flights are integrated. Once the CAP Integration Implementation Plan is coordinated, further CAP coordination for the purpose of integration should be on a specific Payload basis for freeflyer and planetary missions.

2.2 RECOMMENDATIONS

1.) Crew Skills and Level of Operation Definition

The projected payload specialist crew skills and level of operation should be defined in more detail by the Payload Centers and coordinated with Orbiter crew skills definitions.

The projected Orbiter crew skills and the level of payload operations with which they will be involved should be defined in detail. This could be initiated in the following categories.

a. Baseline operational skills and levels.
b. Optional operating skills which are dependent on training time available, flight rate, flight timeline scheduling, etc. These must be addressed during initial flight design and then coordinated during timeline integration.

2.) Shuttle Crew "Overhead" Requirements Definition

The overall Orbiter crew "overhead" requirements and guidelines should be discretely defined as one of the initial sets of CAP data for STS Operator and Payload Center coordination. Specific data items with associated work/rest information should be developed and sent to the Payload Centers and coordinated per Recommendation 3 below. Proposed formats in the CAP Integration Implementation Plan can be used for this purpose.

3.) CAP Integration Working Group

A CAP Integration Working Group should be established to implement the Crew Activity Plan Integration.

A direct dialog and the communications channels should be initiated at the working and integration level. The group should be formed from the personnel who would be involved in future (operational timeframe) CAP integration activities. Topics which should be addressed to initiate communication channels include:

- o Exchange of flight scheduling and planning experience.
- o Identification of CAP Operating Policies at the Centers.
- o Identify desired or assumed activities by each Center - resolve differences by working interface agreements.
- o Integrated CAP software development.
- o Establish data exchange schedules.

The group should include all NASA Payload centers and the JSC Orbiter planners but should not delay because a center may not be involved in an early payload flight and does not choose to participate at its initiation. Early implementation of this working group will allow active participating in OFT and early operational flights to aid in orderly development of CAP integration techniques applicable to the operations timeframe.

4.) STS Operator CAP Crew and Orbiter User Guide

A Crew Activity Planning User's Guide should be developed which contains all of the STS Operator Crew and Orbiter data that is required for Payload Center CAP planning. The User's Guide is non-flight specific covering Orbiter and crew operational capabilities.

Crew "Overhead" requirements (Recommendation 2) will be a part of it, as well as Orbiter CAP timeline/scheduling data.

A goal of the User's Guide will be to standardize crew and Orbiter data for all the flight types allowing minimal updates for specific flights.

5.) Timeline profile data coordination activities should be initiated between the STS Operator and the Payload Centers for the specific definition and requirements of CAP Implementation Plan profile data format(s) for direct computer processing at all Centers. The profile data may be a calcomp tape input, tabular computer printout, or a raw timeline correlated mag tape. Profile data identifies the Orbiter and payloads systems interface data which drive resource/consumable analyses, communications, planning, CAP timelining, etc.

6.) CAP Integration Implementation Plan

A Crew Activity Plan (CAP) Integration Implementation Plan, is recommended for payload planning integration with the STS Operator activities.

The CAP Integration Implementation Plan is a "Draft" document which identifies planning and integration concepts. Because of the nature of the different types of Shuttle payload flights, more than one type of planning and integration process has been identified. The major flows explained are:

- o The "baseline" serial flow, which will normally be the accepted data exchange process.
- o The "parallel" planning and integration flow which is consistent with high Payload Center involvement and complex interactive crew operations. (Such as Spacelab)
- o The "Serial" planning and integration flow which is consistent with a low level of interactive crew operations. (Such as free-flyers)

The enclosed Plan in Section 3.0 of this report discusses these situations, the data, and application of the flows.

7.) CAP Software Development Priorities

The CAP software should be developed on the basis of need. Segmented capabilities can be developed and integrated later as other CAP

planning philosophies and operations mature.

The following list of items for potential CAP software development are listed in order of priority.

CAP Form Generation
CAP Data Storage and Retrieval (Scheduling Data/Criteria)
Timeline Plotting and Scheduling (Terminal Operations)
Timeline Plotting, Automatic Retiming and Rescheduling based on updated orbit parameters and time
Constraint Analysis of Plotted Timelines and Schedules with identification of conflicts (not automatic rescheduling)
Constraint Analysis Scheduling/Rescheduling on an Interactive Terminal Concept

8.) Scheduling Data/Criteria Organization

It is recommended that a common format for all centers be established to provide access to the data and scheduling criteria necessary to produce an integrated timeline both premission and real-time. Data necessary for integration into the STS Operator's timeline can be identified on a different level from the supporting scheduling criteria, needed only for payload operations scheduling.

This can be implemented at several levels of automation and still be effective for data transfer. One option would be a common data base for all centers and remote terminals at each center for data retrieval (with a common format for scheduling data).

A less desireable, but workable, option is that of allowing access to each center's planning data base by all other centers (with safeguards implemented to protect the data base from accidental modification). This option, of course, poses communications and format compatibility problems but is workable if all centers agree to the approach. The third and simplest option is to publish all scheduling

data/criteria in document form for use by the payload centers and STS Operator. This should be in a format similar to previously developed mission requirement documents. For any option, the responsibility for keeping the data current and maintaining the data base belongs to the center supplying the data.

2.3 UNRESOLVED ISSUES

1.) Preflight CAP Optimization vs Real-time Replanning

One unresolved problem is the question on the degree of optimizing a crew activity plan in real-time versus developing a preflight CAP and accepting the results for real-time. The problem is one of accepting the risk of obtaining less than optimum data in return for the cost of ground and onboard replanning in real-time. In a seven day flight this cost could be extremely high for the benefits gained.

The prime potential solutions include:

- o Replanning limited to real-time changes within discrete guidelines.
- o Limiting CAP ground support to a one-shift basis.
- o Total CAP ground support with periodic replanning.
- o Operation ground monitoring and CAP assistance for real-time changes by nondedicated personnel (i.e., 24 hours operations monitoring by systems or instrument personnel and ON-CALL CAP for major approved changes).

2.) Onboard Timeline Format

An orbiter onboard hard-copy display device for CAP uplink data should be identified for the Shuttle operational timeframe. Formats of uplink CAP and potential contents of data are dependent on the device and cannot be adequately identified or designed until the

device and its capability are known.

3.) CAP Preflight Timing Uncertainty

Orbital uncertainties, because of the potential variability of launch time and associated launch trajectory parameters, are a problem to preflight crew activity planning.

This problem is not new to preflight CAP planning, however, if it is prevalent during frequent periodic flights, the updating and rescheduling could be very costly and time delaying. Any launch delay or other time input can require a total rescheduling of all observations and events, and complete replanning of the mission.

This problem tends to place emphasis on software and the reaction time software provides, however, priorities should be assigned and cost-traded before complex software is developed (see Recommendation 7, for CAP software development).

4.) Implementation of CAP Integration

With this final report is the draft of the Crew Activity Planning Integration Implementation Plan. We still feel that this methodology is an open issue and the most effective way to bring about an agreeable method for Crew Activity Planning is through the iterative process of review and refinement of this plan. We recommend that the review of the attached Implementation Plan be the first agenda item for the recommended Crew Activity Planning Working Group with representatives from each center participating. Crew Activity Planning and its integration into one workable timeline is still an open issue - and need not be. This can be resolved by the timely organization and participation in a Working Group specifically addressing Crew Activity Planning.

3.0 CREW ACTIVITY PLANNING INTEGRATION IMPLEMENTATION PLAN - DRAFT

3.1 INTRODUCTION

3.1.1 PURPOSE AND SCOPE

The purpose of the CAP Implementation Plan is to define an approach to the integration of the payload operations with the crew and Orbiter operational requirements.

The plan defines a method, the forms and data required to integrate the payload CAP, Orbiter CAP, and the resulting STS Operator CAP.

The scope of this plan covers only the on-orbit activities of payload and orbiter operations. Launch, orbit insertion, deorbit and landing are only referenced in this plan. These crew activities will be provided separately by Orbiter CAP planning and added to the on-orbit operations for a total CAP.

The description of the CAP integration method and the process of crew activity planning is contained in Section 3.4. Section 3.6 contains detailed CAP integration data and forms.

A companion document describing crew activity planning techniques is used as a baseline for this plan. JSC Crew Activities Planning Techniques document (JSC 09301) should be used for additional details and history of CAP(s).

3.1.2 ASSUMPTIONS AND GROUNDRULES

1.) JSC as the STS Operator is the Crew Activity Plan integrator for all NASA Flights.

2.) This Plan has been developed for NASA payloads integration and may require future modifications for DOD payload integration.

3.) This Plan is prepared for use during the Shuttle Operational Timeframe but is applicable during Orbital Flight Test.

4.) Shuttle Crew Activity Planning is an activity included in the overall "Flight Planning" of a funded or committed flight. (Ref. JSC Memo, reference 5). The two phases of the funded, committed Flight Planning are:

- o Utilization Planning - Analysis of approved payloads
  Preliminary flight design
  Initial operations planning
  Initial crew activity planning
  Start of training planning
- o Detailed Flight Planning - Flight design
  Crew activity planning
  Operations Planning
  Training

5.) A Crew Activity Plan (CAP) is the documented result of crew activity planning, consisting of timelines, and the procedures and crew reference data necessary to accomplish a flight. This Plan involves the integration of the various timelining efforts at the Payload Centers and the STS Operator.

6.) Payload Center Crew Activity Planning data to be submitted to the STS Operator shall be limited to the data required to integrate the payload, crew and orbital operations. (i.e. payload "stand-alone" activities are not required in the interchange)

7.) This Integration Plan covers only the "on-orbit" activities of payload and orbiter operations.

8.) Payload Center CAP data should be in the form of major Payload CAP planning time blocks, orbiter interactions required, and specific orbiter crew requirements.

9.) CAP General Scheduling Criteria data for Payload events, operations and experiments/investigations should be submitted to the STS Operator only when an activity requires integration which:

- o Cannot be fully defined on a Summary Timeline
- o Requires special orbiter support or orbiter crew assistance
- o Requires special coordination between Payload and STS CAP planners.

10.) Real-time crew activity planning is expected in the Operational Timeframe, however, standardization of planning elements should be a goal for minimizing complexity, manpower and cost of flight support.

3.2 CREW ACTIVITY PLANNING INTEGRATION DEFINITION

This section addresses the basic definitions and explanations of Crew Activity Planning. It summarizes the type and format for typical onboard and ground timelining as well as generic integration responsibilities.

3.2.1 CAP - CREW ACTIVITY PLANNING

Crew activity planning is the analysis and scheduling of payload and orbiter activities to be performed on-orbit by the flight crew. This planning results in timelines, associated procedures, data for on-orbit activities and the related ground operations in direct support of the flight.

The Crew Activity Plan (CAP) identifies the sequence of events, specific operational data, procedure references and the overall crew work/rest and overhead activities for the flight. The CAP is one of the major ground control interfaces, as well as the

on-orbit operations plan.

The Crew Activity Plan (CAP) can be divided into:

- o the "onboard CAP", which is prepared for use onboard by the crew, either included in the launched Flight Data File or uplinked periodically,

- o the "CAP Timeline(s) (with related backup data) developed as the prime comprehensive crew activity scheduling tool, during ground planning, from which the on-orbit CAP is prepared.

The on-orbit CAP consists of a Timeline and a set of "Execute Data". The Timeline is an event schedule for all crewmen with timing identified. The "Execute Data" is a specific timed events and operating data listing prepared individually for each crewman.

3.2.2 CAP TIMELINE

The development of the CAP timeline requires the scheduling of the events and crew activities from the specific flight data of:

- o FLIGHT/MISSION REQUIREMENTS
- o PAYLOAD EXPERIMENTS & INSTRUMENT OPERATIONS
- o ORBITAL EPHEMERIS DATA
- o CREW SCHEDULING DATA
- o ORBITER AND SPACELAB OPERATIONAL CRITERIA AND CONSTRAINTS
- o SYSTEM CHECKS, MAINTENANCE & HOUSEKEEPING

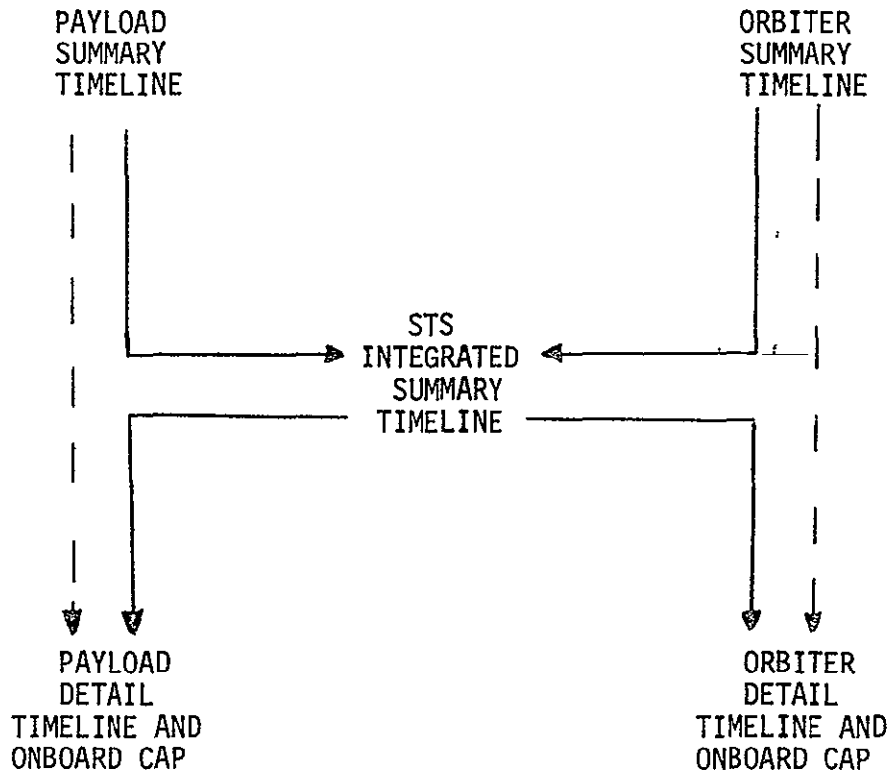
Typical Shuttle formats comprised of an integrated Crew Summary timeline and a Profile data timeline are given in Figures 1 and 2. A typical onboard CAP for one crewman is given in Figure 3. The descriptions of these figures accompany each figure

3.2.3 SHUTTLE CAP TIMELINES AND INTEGRATION SUMMARY

The development process of the CAP Ground and onboard CAP timelines

for Shuttle will involve separately developed Payload Operations and Orbiter Operations Timelines at the summary level. An STS Integrated Summary Timeline will be developed from these inputs.

The Summary timeline will normally be adequate for integration purposes but may not be detailed enough for onboard CAP data preparation. Therefore, following integration, separate detailed timelines for Payload and Orbiter may be prepared. These detailed timelines may be used for preparation of onboard CAPs and execute data. An abbreviated flow of these timelines is shown below.



CAP TIMELINE FORMAT

Figure 1 is an example of a typical completed STS Integrated Summary timeline. This form was developed as a suggested format based on an analysis of numerous potential Shuttle payloads.

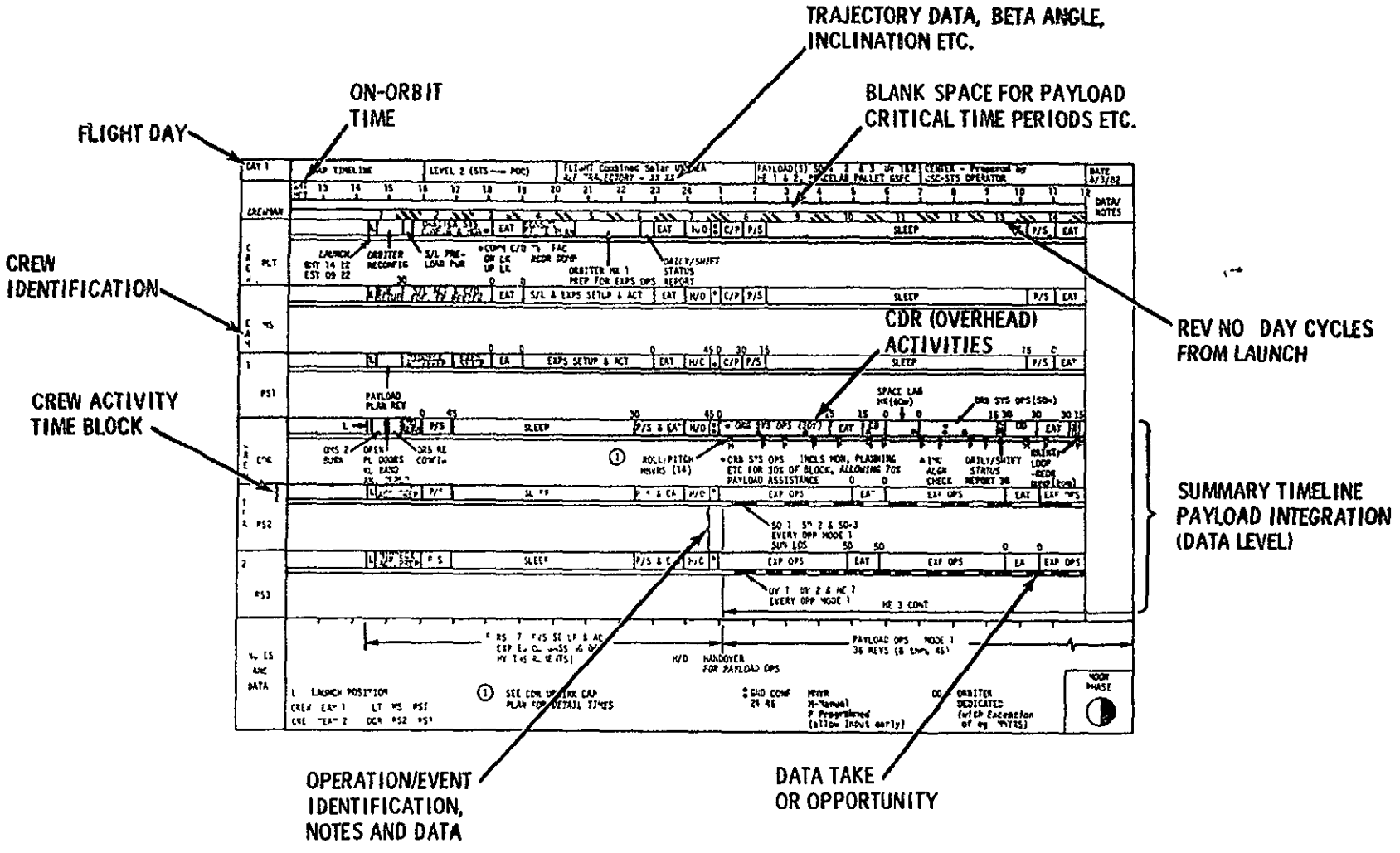


FIGURE 1 - CAP TIMELINE FORMAT

Different mission and flight complexities may require more or less detail depending upon the payload operation requirements.

The form is designed to show the integration of several major aspects·

- o Crew overhead time block activities and major responsibilities
- o Experiment/investigation data-take opportunities, target acquisition periods, and other pertinent experiment information
- o Payload experiment/investigation activities data, specific scheduling and integration data

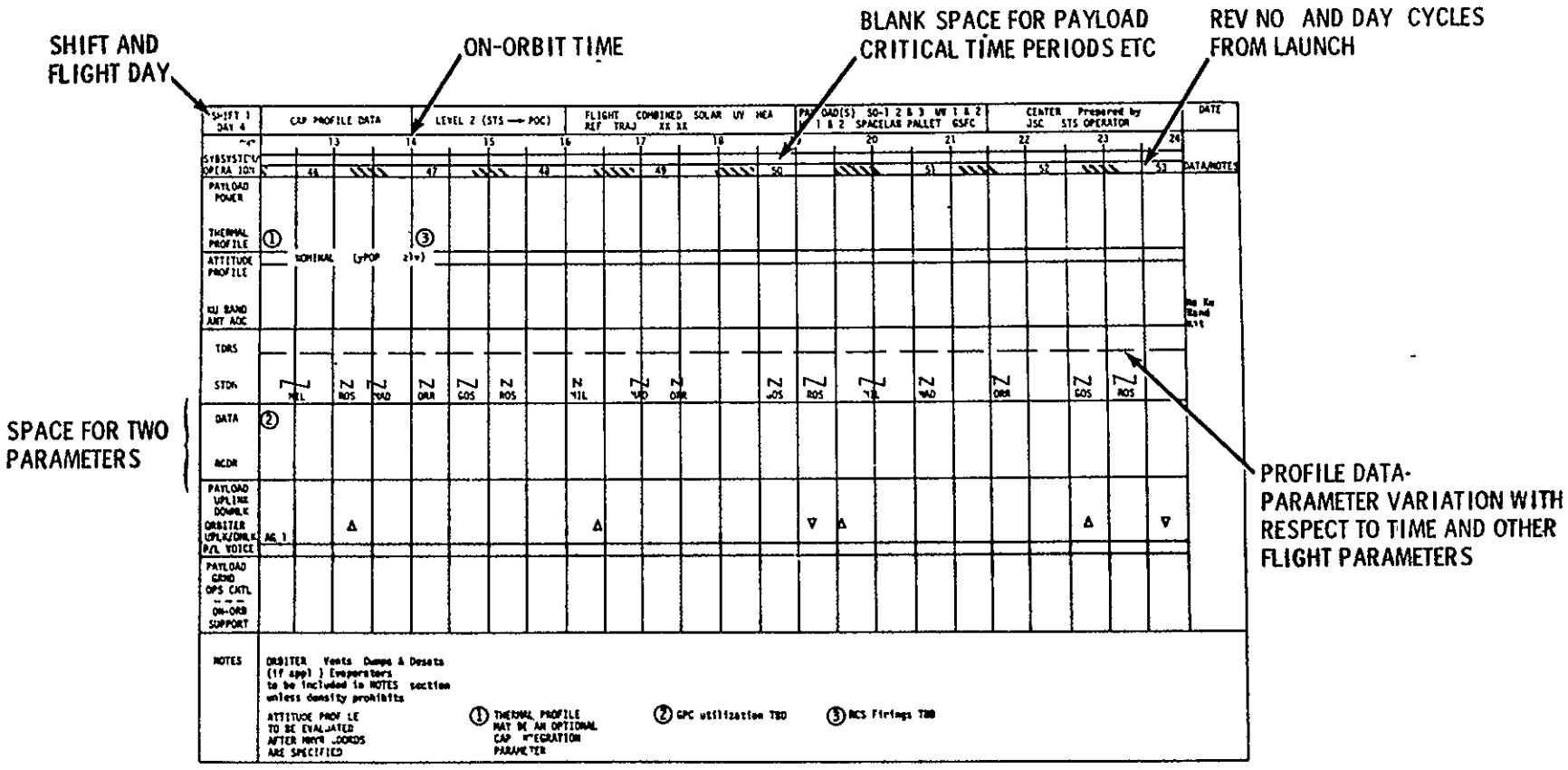
It provides for the logical grouping of crew members into teams and allows a complete 24 hour presentation of each crew member's activities. It presents trajectory data as well as specific experiment operations opportunities for each crewman.

Notes and additional data may be provided at the bottom where supporting information is required. A discrete advantage of the form is that it allows visibility of the separate Orbiter operations as they are related to the generalized summary level Payload operations. The sample plotted data as shown in Figure 1 represents an integrated Summary level timeline.

TIMELINE PROFILE DATA FORMAT

As noted above, the CAP summary timeline does not include detailed trajectory, systems, or attitude profile data. These data are presented on a companion Timeline Profile Data form (Figure 2).

The Timeline Profile Data form is essentially a part of the timeline but is separated for added versatility and visibility. Because a considerable number of these types of parameters are necessary for overall planning and timeline preparation, this format is included.



NOTE- THE DATA ON THIS FORM REPRESENTS FIRST CUT STS PLANNING - PAYLOAD DATA TBD BY PAYLOAD CENTER

FIGURE 2 - TIMELINE PROFILE DATA FORMAT

A typical completed form (shown in Figure 2) is plotted for 12 hours. The scale used (e.g. 12 or 24 hours) will depend on the granularity desired. This sample shows only the Orbiter related parameter profiles. The payload parameters will be added during integration. This form includes the pertinent parameters for each specific flight, including resource utilization tracking.

ONBOARD UPLINK FORMAT

The onboard CAP, Figure 3,is typical of a single CAP uplink for a crewman. This uplink format is designed to convey to the crewman the results of ground replanning with correlateable specific details and data. These include specific "on-station" times, durations of specific events and execution instructions when required. The form has a vertical activity "blocked" time for the overall plan and a specific time related data/ instructions space for the details. The individual uplinks, as in the sample, should show the relationships and working interfaces with the other crewman such that full coordination is obtained without reviewing other crewman plans. All the individual plans comprise the complete CAP for that shift.

The data, notes and instructions to prepare the onboard CAP will come directly from the ground CAP Timelines and execute data. The crewmen may require uplink of detailed execute data for highly specialized onboard operations.

3.3 CREW ACTIVITY PLANNING DATA

Planning data supporting the CAP development exists in three categories:

1.) General Scheduling Criteria - those data that exist relating to flight vehicle or payload guidelines and constraints, crew guidelines and constraints, ground systems utilization and constraints, and the like. Also falling in this category

UPLINK CAP "PLAN" (AND DETAILS)

CMN CDR DAY 1 SHIFT 2

NO. 501 REV. B

DATE 08/03/82

GMT	CAP	TIME	CMN DETAILS DATA/INSTRUCTIONS
22:00	SLEEP	__:__	
30		__:__	VEHICLE ATTITUDE
23:00	PS & EAT	__:__	R/90°, P/90°, Y/90°
		__:__	
		__:__	
24:00	H/O	24:00	HANDOVER TO CDR, MS, PS1
45		24:45	GRND CONF - MIL (12 MIN)
1:00	GRND CONF	__:__	
	ORB SYS OPS	__:__	
		__:__	
2:00		2:16	MNVR - R/180°, P/95°, Y/40°
		__:__	(3.2 MIN)
		__:__	
3:00		__:__	
	P/L SUP. (TO PS2 PS3)	__:__	
4:00		__:__	
		__:__	
45		4:45	MNVR - R/90°, P/90°, Y/90°
5:00		__:__	(3.2 MIN) THERMAL NOM
	EAT	__:__	
		__:__	
6:00		6:02	ORD OPS 32-10, GPC CODE
	ORB OPS	__:__	"EXC 3212" (10 MIN)
45		__:__	
7:00		__:__	MNVR - R/120°, P/90°, Y/60°
	P/L SUP	7:29	(3.0 MIN)
		__:__	
8:00	(TO PS2)	__:__	
		__:__	
		__:__	
9:00		8:50	MNVR - R/90°, P/90°, Y/90°
	ORB HK 610	__:__	(3.0 MIN) THERMAL MON
		__:__	
10:00	H/O REPORT PREP	__:__	
30		__:__	
11:00		__:__	
	EAT	__:__	
30	H/O	11:30	HANDOVER TO PLT, PS2, PS3
12:00		__:__	
	PS	__:__	
		__:__	
13:00		__:__	
30		__:__	
	SLEEP	__:__	
14:00		__:__	

FIGURE 3 - ONBOARD UPLINK TIMELINE FORMAT

are those data which may pertain to any service or support function (i.e. Spacelab systems constraints or payloads/ experiments on Spacelab missions). Those general scheduling criteria exist for each flight vehicle (Orbiter and payloads) but what data exists as general scheduling criteria for a specific payload center's payload may not be relevant to the CAP integration process unless it imposes an operational constraint on the Orbiter or crew. Hence, general scheduling criteria apply to Orbiter, crew and support system guidelines and constraints in the integration process.

2.) Flight Specific Integration Data - those data required to allow the payload and Orbiter crew activity plans to be made compatible. These data initially include trajectory parameters, gross mission and flight requirements, and gross crew availability requirements. As the timeline development proceeds, these data requirements become more stringent and include specific attitude, trajectory, ground support, Orbiter support, and Orbiter crew support requirements. These data can flow both ways, as the CAP integration process is iterative (i.e. a flight specific requirement for Orbiter attitude profile may generate an Orbiter thermal or power constraint requiring feedback from the Orbiter planners to the payload planners). Flight Specific Orbiter constraints may also exist at the outset of the planning cycle and require conveyance to the payload planners.

3.) Payload Activities Scheduling Criteria - those data applicable only to developing Flight Specific Integration Data or to the independent operation of the payload (i.e. specific pointing targets, starfields, data take times). If the payload center is developing its own payload CAP, these data are not normally required by the integrator. On certain complex activities requiring precision interfaces between Payload

and Orbiter operations, however, this data exchange may be required. When the Orbiter planners have been designated by the payload center to develop the payload crew activity plan and hence to perform the entire planning and integration task, all Flight Specific Data and Payload Activities Scheduling Criteria are required.

3.3.1 GENERAL SCHEDULING CRITERIA

General CAP scheduling criteria are those data that can be used and referred to when scheduling an event or activity. It needs to be distributed to all those required to schedule or revise CAP activities. Ordinarily, detailed payload scheduling criteria will not be required by the STS Operator for CAP Timeline integration, however, there will be situations when details are necessary to effect integration or real-time rescheduling.

General scheduling criteria should be exchanged between the Payload Centers and the STS Integrator and be maintained in a current status. These criteria should be available three to six months prior to timeline integration depending on the complexity of the crew activities. The Payload Centers will be responsible for all Payload operations scheduling criteria including the interfaces with the Orbiter and overall crew. The STS Integrator will be responsible for the overall crew scheduling criteria, payload and orbiter crewmembers, and the Orbiter operations scheduling criteria.

The mutual understanding of each other's scheduling criteria is essential for minimizing rescheduling iterations. This knowledge will also reduce the interfacing during scheduling and rescheduling. The following lists of scheduling criteria are given as potential CAP integration data.

ORBITER SCHEDULING CRITERIA AND GUIDELINES

- Thermal profile limits/solar exposure requirements
- Pointing accuracies and stability

- o Stabilization rates and drift rates
- o RCS & VCS firing effects and frequencies
- o Venting and dumping schedules
- o IMU alignments and Navigation updates frequencies
- o Orbiter communications equipment utilization groundrules
- o Housekeeping requirements
- o Ground control planning guidelines for Payload operations
- o Payload utilization and scheduling of Orbiter capabilities:
  - oo RMS
  - oo Orbiter KB-CRT Requirements for payload operations
  - oo Audio (Air to Ground & Intercom)
  - oo Science Data Downlink
  - oo Uplink (Commands & Update link)
  - oo CCTV
  - oo TV Cameras
  - oo GN&C Payload Interface
  - oo Docking Module
  - oo Tunnel Adapter
  - oo EVA Equipment
  - oo Airlock
  - oo Manned Manuevering Unit
  - oo Rendezvous Tracking
  - oo Payload Power
  - oo Payload Bay Lighting

OVERALL CREW SCHEDULING CRITERIA AND GUIDELINES

The overall crew scheduling criteria will apply to all crew members, payload and Orbiter. It will include nominal times, allowed variance, and the scheduling groundrules for placement of the time blocks.

- o Nominal crew physiological requirements
  - Eat times
  - Sleep
  - Post sleep activities

Pre sleep activities
Rest periods (as applicable)
Exercise
Personal hygiene
Shift length
Maximum allowable crewman work hours per day

- Standard crew activities
  (times, frequency, crewman assigned and scheduling rules)
  Shift handover
  Daily status reports
  Crew activity planning
  Consumables checks and Planning

3.3.2 FLIGHT SPECIFIC INTEGRATION DATA

The flight specific CAP data should be the only data exchanged for every flight once the General CAP Scheduling Criteria have been initially defined, distributed and stabilized.

Flight specific data can be in the form of the CAP Timeline (i.e. Summary level), however, the potential exists that a scheduled event on the Summary timeline will not contain enough detail for integration, therefore, additional data may be required. Backup data may include items such as manuever coordinate tables, star charts, and scheduling sequences for complex payload events.

The responsibility of providing flight specific data is divided into 1) the items the Payload Center must provide for integration and 2) the items the STS Operator must schedule or provide for on-orbit activities.

The results of this separate scheduling will be the Payload Summary Timeline and the Orbiter Summary Timeline. The STS Integrated Summary Timeline will be the combination of these, as adjusted for time availability, conflicts, time critical events, and constraint violations.

The following are representative of Flight Specific Data:

PAYLOAD FLIGHT SPECIFIC INTEGRATION DATA

- o Payload operations time blocks for the:
  - o Payload Specialist(s)
  - o Mission Specialist (when applicable)
  - o Commander (when applicable)
  - o Pilot (when applicable)
    - These time blocks must include related integration data, either plotted or noted:
      - Critical Orbiter operation start/stop times, imposed orbiter constraints, crew support requirements
- o Payload utilization of Orbiter equipment/systems
  - This data should be correlated to the time blocks, either in the block or in the notes space at the bottom of the timeline.

  i.e.
  - o COMM - Uplink/Dwnlk - KU Band
    S Band
  - o CCTV - System & Cameras
  - o Bay Lighting
  - o RMS
  - o MMU
  - o EVA Equipment
  - o Recording (rate & volume)
- o Payload data for orbiter support. Examples:
  - Attitude/pointing - position
    - o Roll
    - o Pitch
    - o Yaw
  - Time - at attitude start/end
  - Manuever constraints (eg. rate)
  - Deadband requirement

Conversely, the Orbiter responsible planners/STS Integrators must provide any flight specific data in the following area.

ORBITER FLIGHT SPECIFIC INTEGRATION DATA

- o Orbiter operations: Orbiter HK & maintenance for Orbiter Crew
  - o Commander
  - o Pilot
  - o Mission Specialist

- o Overall crew (payload & Orbiter) health, welfare and general activities including: Eat, Sleep, Hygiene, Pre/post sleep, Status briefings (downlink), Handover periods

  (This can be accommodated by General Scheduling Criteria if no flight peculiar modifications are necessary)

- o Utilization of Orbiter equipment/systems

  - (Initially only Orbiter requirements, later for integration it will include review of payload requirements.) Examples:

    - o COMM - Uplink/Dwnlk - KU Band
      S Band
    - o CCTV - System & Cameras
    - o Bay Lighting
    - o Recording (rate & volume)
    - o Scheduled RCS firings
    - o Nominal Attitude Profile
    - o Ventings
    - o IMU Alignment
    - o Thermal control periods

- o Orbiter operations scheduling to support payload operations.

i.e.

- Manuever start time
- Manuever rate
- Duration of Manuever

Typical formats for organizing these data that is applicable to the integration task is included in Section 3.6 as Supplemental CAP Data Forms.

3.3.3 PAYLOAD ACTIVITIES SCHEDULING CRITERIA

These data are required by the Payload Center for the Payload CAP and may be required by the STS Integrator when that organization is performing the entire scheduling task for a specific payload.

- o Payload operations constraints - (eg. Orbiter motion, RCS contamination)
- o Crew assignment, skill specialities, limits
- o Pointing requirements
- o Vehicle attitude requirements
- o Power levels and profile
- o Data recording and downlink requirements
- o TV recording and downlink requirements
- o Orbiter equipment/system utilization
- o Data take times
- o Specific start/stop times for experiments
- o Radiation requirements
- o Photo requirements
- o Lighting constraints
- o Venting
- o Target identification
- o Experiment/operations priorities

Representatives formats for this data may be referenced in Section 3.6

3.4 STS/PAYLOAD PLANNING INTEGRATION FLOW

Crew Activity Planning and particularly the integration of plans is an iterative process. It is difficult to assess the point at which one level of detail or integration ends and another level begins. The flow and counterflow of data is dependent upon the level of sophistication of the payload, the inflight activities, and the planners involved. The early exchange of general scheduling criteria will aid the early identification of possible conflicts and constraint violations. The more sophisticated and capable the payload center's planning team and the more refined the scheduling data at the outset of the planning cycle, the fewer iterations are required to develop an effective crew timeline.

This section will address the baseline integration process of a mature operational timeline or Crew Activity Plan. Included are two variations of the baseline flow which are feasible for specific payloads and payload planner expertise.

3.4.1 BASELINE INTEGRATION

Crew activity plan integration combines the summary level Payload, Orbiter and Overall Crew operation planning into an STS Integrated Summary Timeline. The STS Integrated Summary Timeline then becomes the coordinated and agreed upon basis for detailed planning and scheduling of Payload and Orbiter operations and development of execute data.

The timelines developed by the Payload Center and the STS Operator will initially be based on the "flight-specific" data developed during Utilization Planning and Flight Design.

The initial flight-specific data is required to plan:

- The orbital trajectory and related parameters (including ground track, Communications coverage, etc.)
- The flight peculiar Summary Crew work/rest schedule

From these two items the Payload Center can tentatively schedule operations on a time block level for integration at the Summary level. The STS Operator can tentatively schedule Orbiter operations with both planning groups realizing that some minor conflicts can occur which will be resolved during integration. Conflicts should be reduced once the general CAP scheduling criteria which must be exchanged between the Centers prior to any flight specific crew activity plan scheduling are understood.

The time block level of scheduling refers to a period of time available to perform an activity, rather than the actual functions performed in that activity. Some specific functions must be coordinated with a related Orbiter operation, such as an observation requiring a specific attitude. A sample of the time block level of scheduling is shown below.

SAMPLE TIME BLOCK (for integration at the summary level)

Typical Orbiter Crewman operations

MNVR	ORB OPS	MNVR P/L OPS	ORB HK	EAT	P/L OPS Support	MNVR	OPEN	H/O	EAT	PS	SLEEP
12:30		14:45	16:00			21:00	22:30				

Typical Payload Crewman operations

S/L HK	P/L OPS	EAT	P/L OPS	P/L OPS	H/O	EAT	PS	SLEEP
12:30	14:45	16:02		21:00	22:30			

A summary Timeline form and related data forms for the scheduling of CAP operations are provided in Section 3.6. A discussion of the range of data which must be identified on the Summary Timeline will follow in a subsequent paragraph on CAP Integration data.

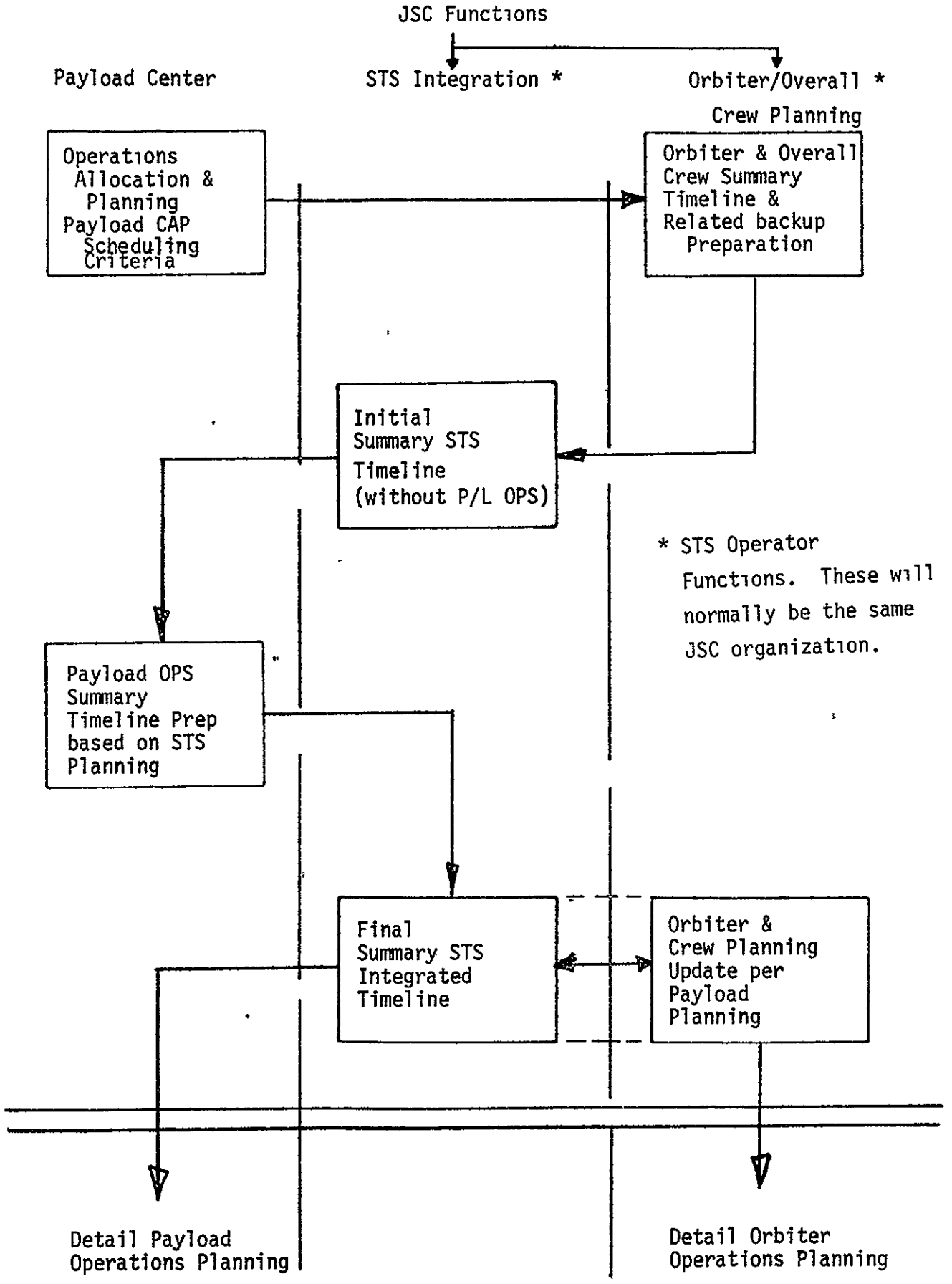


FIGURE 4 - BASELINE SERIAL INTEGRATION FLOW

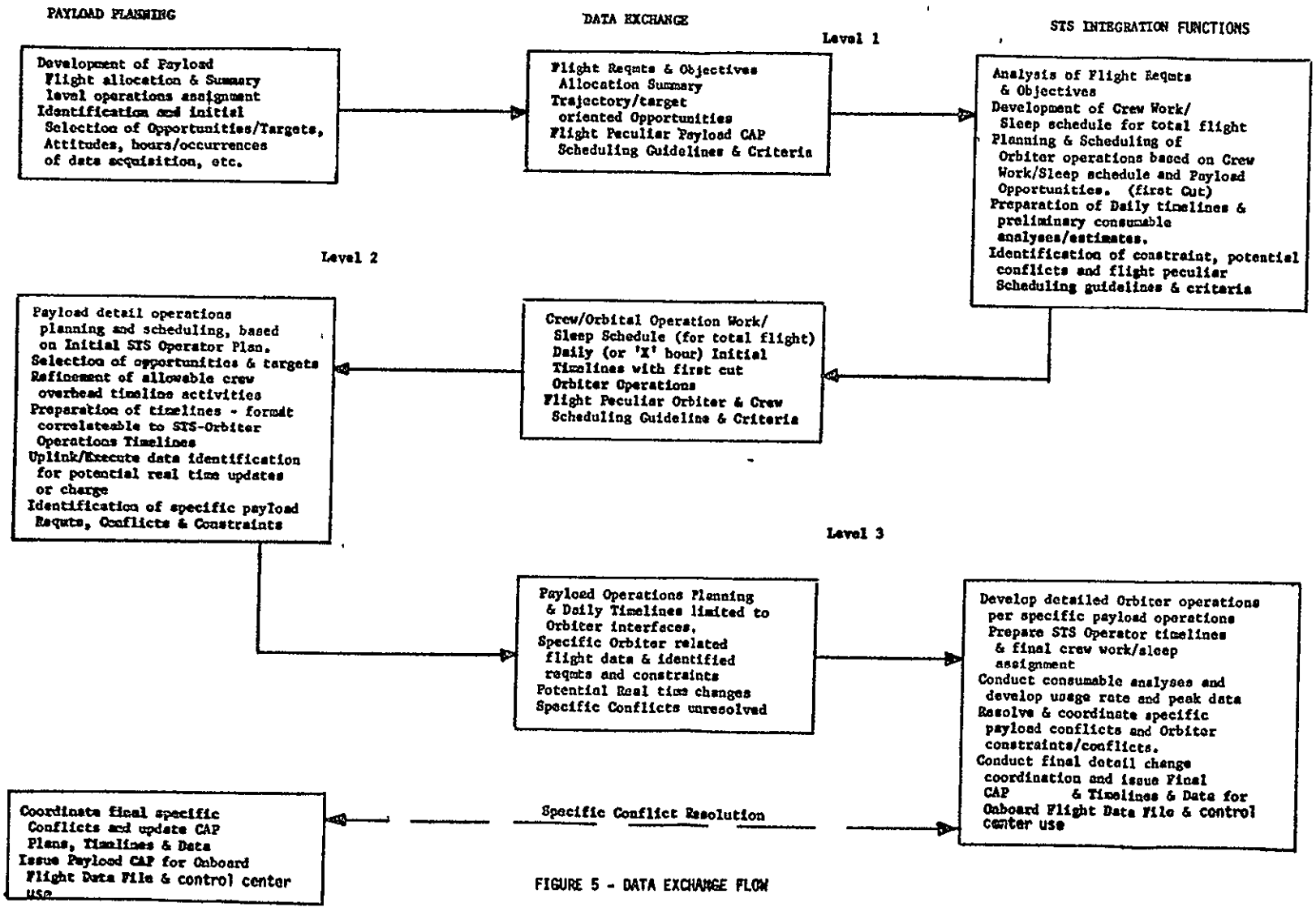


FIGURE 5 - DATA EXCHANGE FLOW

3.4.2 BASELINE INTEGRATION FLOW

The baseline or most often utilized integration flow will consist of three basic data exchanges or iterations in the Crew Activity Planning process. For the purpose of this discussion these exchanges have been identified as levels of integration. The description of this flow is presented by a discussion and reference to three items in this section - the Overview Flow (Figure 4), the Three Level Data Exchange Flow (Figure 5), and supporting data lists for each level. Specific formats representative of those which can be utilized for this flow are included in Section 3.6

This baseline serial integration flow process involves three levels of data exchange during the crew activity planning timeframe prior to a flight. (Reference Figure 5) The process starts with the Flight Design and Utilization Planning data which is available to both the Payload Center and the STS Integrator. The Payload Center then identifies the CAP flight objectives and requirements and develops the initial CAP data and flight allocation planning. The CAP data applicable for integration of the payload operations into the STS-Orbiter operations and overall crew planning is then defined and becomes - the "Level 1" Flight Specific Integration Data forwarded to the STS Operator. Figure 5 identifies more detailed data requirements. The STS Operator CAP planners then develop an initial integrated CAP which includes daily timelines showing crew work/rest cycles and Orbiter operations. This CAP planning becomes the "Level 2" data forwarded to the Payload Center. The Payload Center then develops a final CAP using the first-cut integrated CAP as a guide and prepares final Payload CAP timelines and associated data. The CAP data applicable for final integration of the payload operations becomes the "Level 3" Flight Specific Integration Data forwarded to the STS Operator. The STS Integrator prepares a final integrated CAP after resolving changes with the Payload Center and issues an STS Integrated Summary CAP. The Detailed Payload CAP may be issued separately

by the Payload Center and similarily a Detailed Orbiter CAP may be issued by the STS Operator. The integration flow process is the same during real-time, the difference is that, preflight, the entire flight crew activity plan is prepared prior to coordination for integration, while in real-time a one day (or one shift) crew activity plan is prepared and coordinated for integration. In real-time the daily (periodic) CAP is usually prepared 24 hours in advance of the actual on-orbit operations.

LEVEL 1 DATA (PAYLOAD CENTER TO THE STS OPERATOR)

Level 1 data is the initial data and preliminary planning done by the Payload Center for a specific flight. It preceeds STS Operator CAP planning in order to provide the STS Operator with initial Payload Center analysis results of overall flight planning and events allocation. (These data could be included in the P/L Flight Requirements Document).

Typical formats for the exchange of these data are given in Section 3.6. The forms are:

- o Payload Flight CAP Allocation Forecast (Figure 13)
- o Supplemental CAP data and instructions (Table I)

The level 1 data essentially consist of:

- o An overview activities timeline showing the preliminary scheduling of flight objectives, requirements and significant related data. The type of data emphasized is the data required by the STS Operator for CAP integration.
- o Basic quantitative and qualitative data of flight objectives, requirements and that scheduling data from the Payload Center CAP data base applicable to STS Operator CAP integration.

This Flight Specific Integration Data includes:

Payload Flight Objectives and Requirements

Identification of CAP Events
- Time Blocks of Payload Operations
- Deployments (IUS, satellites freeflyers)
- Retrievals
- On-Orbit Payload Services
- EVAs
- Manned Maneuver Unit Operations
- Dockings
- Orbiter or MCC Operations to support Payloads
- RMS Operations

Operational Locations (of above events
- Orbiter AFT Deck (C&D and KB/CRT Operations)
- Orbiter FWD Deck (KB/CRT Operations)
- Spacelab Module

Payload Flight Design Characteristics
- Preliminary selection of times and timeperiods for events identified above
- Maneuvers

Payload CAP Scheduling Criteria (Required only for Orbiter Operations interfaces)
- Assignment constraints (e.g. contamination; motion, lighting)
- Crew assignments and limits
- Skill specialities
- Vehicle pointing requirements
- Attitude (per event/opportunity/target)
- Power levels and profile
- Data recording and downlink requirements
- TV recording and downlink requirements
- Orbiter Subsystem utilization

LEVEL 2 (STS OPERATOR TO THE PAYLOAD CENTER)

Level 2 data is the "first-cut" STS Operator, Orbiter and overall crew activity planning based on the Payload Center (level 1) data and details of the Reference Trajectory Plan.

Level 2 data includes:

- o Quantitative and qualitative flight design, Orbiter data and crew data.
- o Crew timelines and system/resource utilization Profile data (timeline)

Typical formats for the exchange of this data are given in Section 3.6. The forms are:

- o Crew Activity Planning timeline (Figure 8)
- o Profile Data (Figure 10)
- o Crew Work/Rest Cycle Schedule (Figure 15)
- o Orbiter/Crew Scheduling Criteria (Table II)

The following data are representative of that presented on the above typical formats and comprise a subset of the level 2 data exchange.

Orbiter flight specific objectives and requirements (Timelined data)

- o Total on-orbit period and times
- o Circularization period and times
- o De-orbit thermal stabilization period and times
- o Flight Specific - other orbiter reserved time periods
- o On-Orbit course changes or corrections
- o Payload Ground Control operation integration
- o Flight Specific Orbiter on-orbit reserved subsystem utilization periods and times (the data required as constraints on payload operation)
  - oo GPC
  - oo Comm-Downlink/Uplink
  - oo Orbiter keyboard/CRT

Note: Groundrules for applying allowed variable requirements should be included in Orbiter Scheduling Criteria and Guidelines.

Flight Design Characteristics (Plotted on the timeline & Profile data form as required)

- o Launch Times, window
- o Insertion Times
- o On-Orbit Times
- o Circularization Times
- o Thermal profile (plan)
  (flight specific)
- o Attitude Profile
- o Earth trace data
- o Moon rise/set
- o Communications acquisition/durations
  - STDN sites
  - TDRS
  - limitations of utilization or modes
- o SAA occurrences
- o Rev. numbering
- o Sun angles
- o Inclination
- o Preliminary attitude profile accessment
- o Antenna pointing versus attitude

Orbiter Scheduling Criteria Guidelines

Note: Normally, this data will have been issued before a specific flight is planned and will not have to be exchanged every flight. Certain portions may have to be updated for each flight.

- o Thermal limit guidelines
- o Pointing accuracies
- o Stabilization rates/drift rates
- o Payload Power (flight specific)

- o Shuttle RCS & VCS Burns/firings (exclusive of Maneuvers)
- o Dump Schedules
- o Venting schedules
- o Navigation Update (frequency, time-attitude change regions)
- o Orbiter data downlink/uplink utilization groundrules for CAPs
- o Orbiter/Spacelab - (standard times and data)
  - oo Power reconfiguration
  - oo Spacelab Activation/Deactivation
- o Orbiter Systems Capabilities
  - oo Limits, use constraints
- o Orbiter - Housekeeping reqms and Crew assignment - flight Specific and Standard
- o Payload Ground Control operation constraints

Crew Scheduling Criteria and Guidelines

- o Nominal Crew Physiological Requirements
  - oo Eat-times and scheduling rules
  - oo Sleep-times and scheduling rules
  - oo Pre sleep periods - Times and scheduling rules
  - oo Post sleep periods - Times and scheduling rules
  - oo Rest
- o Exercise
- o Personal Hygiene (specific activities and/or percent of work time)
- o Shift-length Times
- o Maximum crewman work day hours

Work/Rest Cycle Schedule

- o Flight specific Crew work/rest schedule for the total orbiter crew compliment scheduled for the entire flight
- o Commander-Payload Operation availability

- o Pilot-Payload Operation availability
- o Mission Specialist-Payload Operation availability
- o Team designation

Standard Crew Activities

- o Shift Handover
- o Daily - status reports
- o Consumable checks
- o Consumable planning
- o Activity planning
- o Crew Skill Mix

LEVEL 3 DATA (PAYLOAD CENTER TO THE STS OPERATOR)

Level 3 data are the results of the Payload timeline planning based on the STS Operator level 2 planning. This should represent the detailed planning of the science on-orbit operations in a Summary CAP Timeline level of integration, including changes to the level 2 data as required.

When these data are integrated by the STS Operator only those changes necessary for proper overall operation will be made. Conflicts will be coordinated and resolved as they are noted.

Level 3 data consists of:

- o Payload CAP crew Timelines and profile data
- o Payload operations backup data as required for integration

Typical formats for the exchange of this data are given in Section 3.6. The forms are:

- o Crew activity planning timeline (Figure 8)
- o Profile data (Figure 10)
- o Supplemental CAP data and instructions (Table I & Figure 12)

The following data are representative of that included in the Payload operations planning, level 3 exchange for specific flights.

Payload Flight Objectives and Requirements

(The majority of these data will be scheduled on either the CAP Payload Timeline or the CAP Payload Profile data timeline)

- o Orbiter Maneuver requirements for Payload
- o Flight Specific or Unique Orbiter system utilization requirements
- o Additional CAP Integration Scheduling Criteria
- o Payload CAP timelining constraints
- o Orbiter-Payload "existing" CAP conflicts
- o Orbiter-Payload flight design changes -
  - e.g. Deployment times/duration
    Retrieval times/durations
    Freeflyer Checkout requirements
    Pre-Test of Freeflyers prior to Deploy or Retrieve
    Additional TV Camera Requirements

Crew Scheduling Modifications

Flight specific payload crew member assignments
Orbiter crew special activities or support
Flight specific ground control requirements and Interfaces with crew on-orbit
Orbiter crew activities scheduling adjustments
Unresolved Orbiter crew scheduling conflicts

3.4.3 ALTERNATE INTEGRATION FLOWS

It is apparent that not all payload centers will have the same level of planning expertise, nor all payloads the same complexity and detailed planning requirements. Two alternate flows are presented in a summary manner. One, the parallel flow,

assumes a payload center with a great deal of planning expertise and a complex, interactive payload with a great deal of activity planning already accomplished prior to the integration process. The second, a serial flow, assumes a very simple payload with minimal crew or Orbiter interface requirements and a payload center that requests the STS integrator to provide the total planning effort.

3.4.3.1 PARALLEL INTEGRATION FLOW

The parallel integration flow (Figure 6) shows the Payload Center and the Orbiter Crew CAP preparation starting in the same timeframe. Both will prepare Summary level timelines and provide them with related backup data for the STS Integration.

The STS Integration Function provides review, correlation and compilation of the separate timelines with the objective of keeping the Payload operations scheduling within the groundrules of the Orbiter and overall crew utilization and scheduling. These groundrules will include all Flight Specific Utilization and Flight Planning resource identification,allocation and crew planning agreements.

The STS Integrator will develop a combined STS Integrated Summary timeline with adjusted CAP activities for review by the Payload Center and the Orbiter planners. The necessary timeline adjustments will be coordinated in advance with the CAP planning personnel when changes are of sufficient magnitude to cause major rescheduling. It is necessary for the Integrator CAP planners to work closely at all times with the Payload CAP planners for normal schedule conflict resolution.

Once the STS Integrated Summary timeline has been developed and approved the separate CAP planning areas will prepare

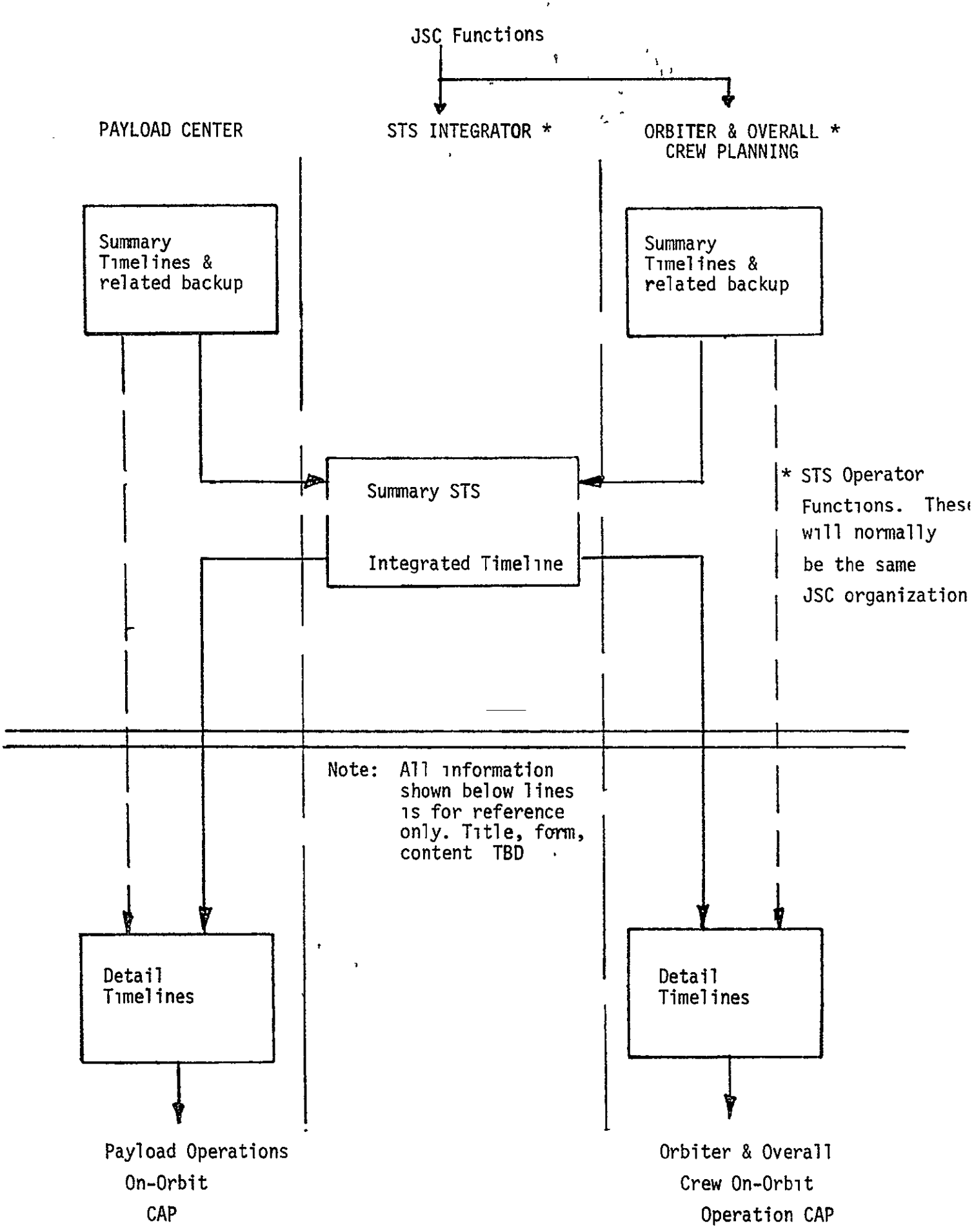


FIGURE 6 - PARALLEL INTEGRATION FLOW

the detailed timelines and on-orbit CAP material. No further coordination is planned at the detailed timeline level, unless changes occur which require coordination.

It should be noted that the parallel integration flow depicts the STS Integrator and the Orbiter & Overall Crew Planning as separate functional entities. This will not normally be the case. Both planning activities will likely be done by a FOD CAP planning group at JSC. The type of Payload that would be assumed to be integrated using the parallel process would be a Spacelab pallet or module payload, where the Payload Center has done a great deal of pre-planning activities. In this situation considerable Orbiter and crew interaction would be involved and the Payload Center would generally be heavily involved in crew activity planning early.

3.4.3.2 SERIAL INTEGRATION FLOW

The serial integration flow, Figure 7, shows a progressive development of the Summary Level timeline. This process starts with the Payload Center preparing an overall operations allocation rather than a discrete Summary timeline. The allocation identifies only the objectives and requirements in a preliminary form. This form shows desired scheduling, but lacks depth in considering Orbiter and overall crew scheduling criteria.

These payload allocation planning data, along with Payload CAP scheduling criteria, is forwarded to JSC where the Payload summary level timeline is prepared with the Orbiter & overall crew Summary timeline to provide the Integrated Summary Timeline.

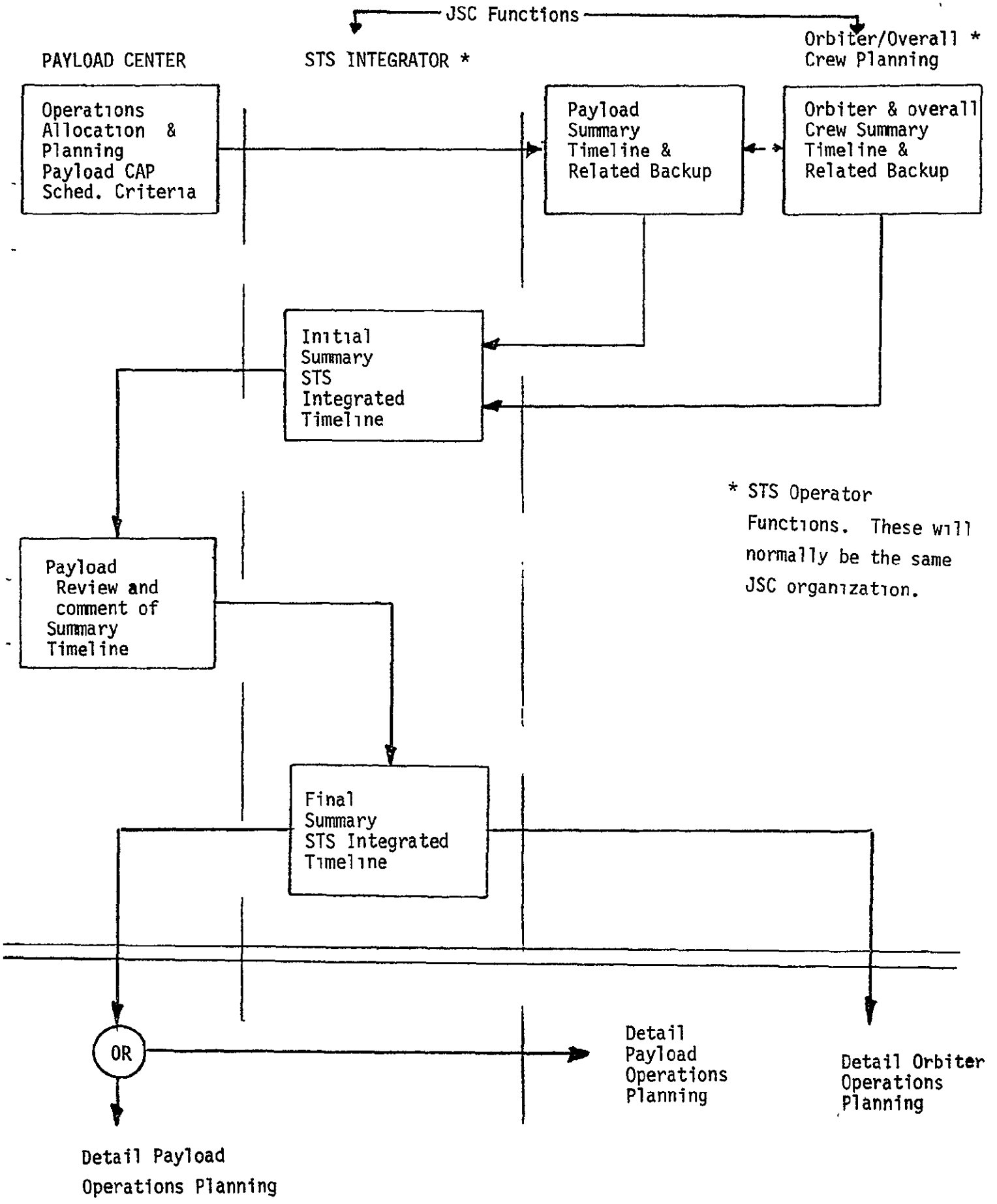


FIGURE 7 SERIAL INTEGRATION FLOW

In this situation the integrated summary timeline is an initial STS Integrated Summary timeline which the Payload Center needs to review for changes during final integration. It is possible that flights that have little payload operations involvement in the on-orbit activities may use this serial flow. Therefore, after the Payload Center review, extensive orbiter replanning will not be required.

After final STS Summary level integration, the STS Integrator will issue a final Integrated Summary for approval. The detailed timeline and onboard CAP preparation will be similar to the parallel integration process, unless JSC is to prepare the detailed level plans and supporting data.

A representative payload that could be integrated as described is a deployed payload that requires minimal on-orbit checkout prior to deployment and is subsequently controlled by a ground station. This type of payload requires minimal crew and Orbiter interaction and should be easily planned.

3.5 CREW ACTIVITY PLANNING MEMORANDUM OF AGREEMENT

The crew activity planning and integration process may be performed in numerous ways for Shuttle. The Payload CAP timelines and data may be prepared independently or with much coordination. The discussions on the types of integration and planning flows in Section 3.4 indicate the possible alternatives and the related responsibilities. Therefore, for each flight, the Payload Center and the STS Integrator should prepare a memorandum of agreement detailing the process for CAP Development and integration. A sample of such an agreement is presented on the following page.

Subject: Payload CAP Planning and Integration

Flight: _____

Payload Development Center _____

Organizations: Payload Center _____

STS Integrator _____

Purpose:

This memorandum of agreement outlines the responsibilities, interfaces and schedules for Shuttle payload planning and integration.

Responsibilities:

The responsibilities for CAP preparation, interface CAP coordination and approval shall be divided between:

- o Payload Center
  - Acting as lead for all payload experimenters and investigators criteria.
  - Responsible for CAP scheduling for all Payload Operations.
  - Preparation of Payload Summary and Detail Timelines.
  - Preparation of Real Time Timelines and Payload Crew Uplink CAP operations data.
- o JSC - FOD Flight Activities Branch
  - Responsible for all Orbiter CAP operations planning.
  - Responsible for the Overall crew, payload and Orbiter, overhead planning and scheduling.
  - Responsible for Orbiter and Overall crew scheduling criteria.
- o STS Integrator
  - Responsible for the coordination and integration of the Payload, Orbiter/Crew Activity Timelines.
  - Resolution of Scheduling Conflicts
  - Issue of STS Integrated Summary Timelines

Interface Definitions:

STS Responsible Planners _____

Location _____

Telephone_____

P/L Responsible Planners _____

Location _____

Telephone_____

Schedule of Data:

(Specific list of data requirements from each party, schedule for deliveries, reviews, and publications)

3.6 CREW ACTIVITY PLANNING FORMS

The following are typical formats for the data exchange and preparation of Crew Activity Plans. Included are blank formats and formats with representative data filled in. All formats are equally adaptable to payload or Orbiter data, and are adaptable to automated storage and scheduling system utilization.

3.6.1 CREW ACTIVITY PLANNING (CAP) TIMELINE FORMAT

The Crew Activity Planning (CAP) Timeline form includes payload operation time blocks and orbiter/crew major support events for timelining by the STS Operator and Payload Center. A companion form, titled CAP Profile Data, is identified separately (3.6.2).

The design of this form allows flexibility in use. It can be used for various periods including 8, 12, 16, and 24 hour. Any time reference may be used (GMT, MET, EST, etc.) however, once adopted, all parties should maintain the same reference. The form has six major rows for activity planning of up to six crewmen. If fewer crewmen are required, the balance of the subset spaces can be removed and used for associated data and notes. The timeline format is flexible and additional crewmen or notes rows may be added as required.

Each Crewman Space allows the layout/timelining of three types of data:

(1) Overhead Planning -
Includes, but is not limited to:
- Orbiter required events
- Work/Rest
- Crew Physiological activity
- (No payload operations)

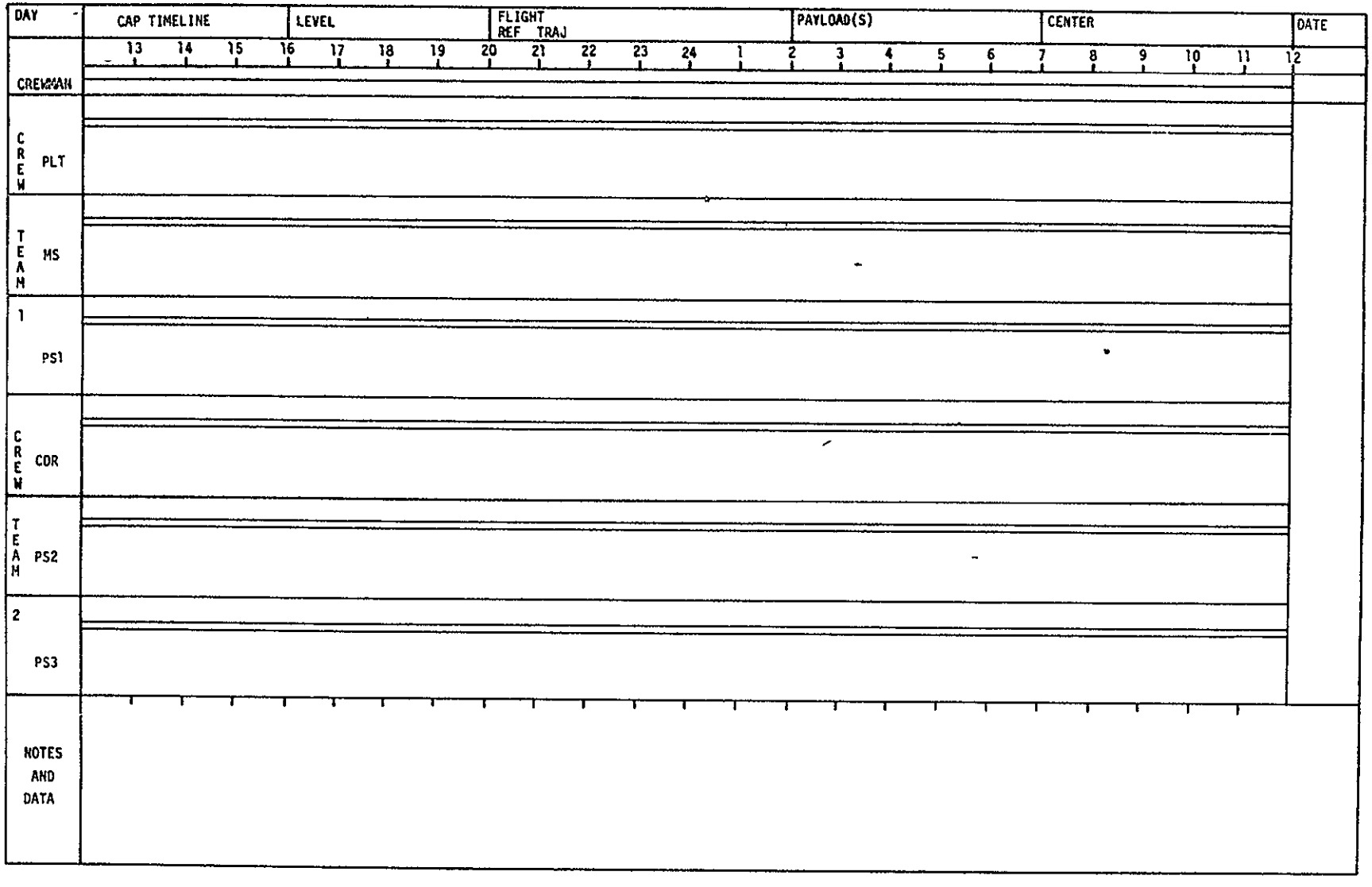


FIGURE 8 - CAP TIMELINE FORMAT

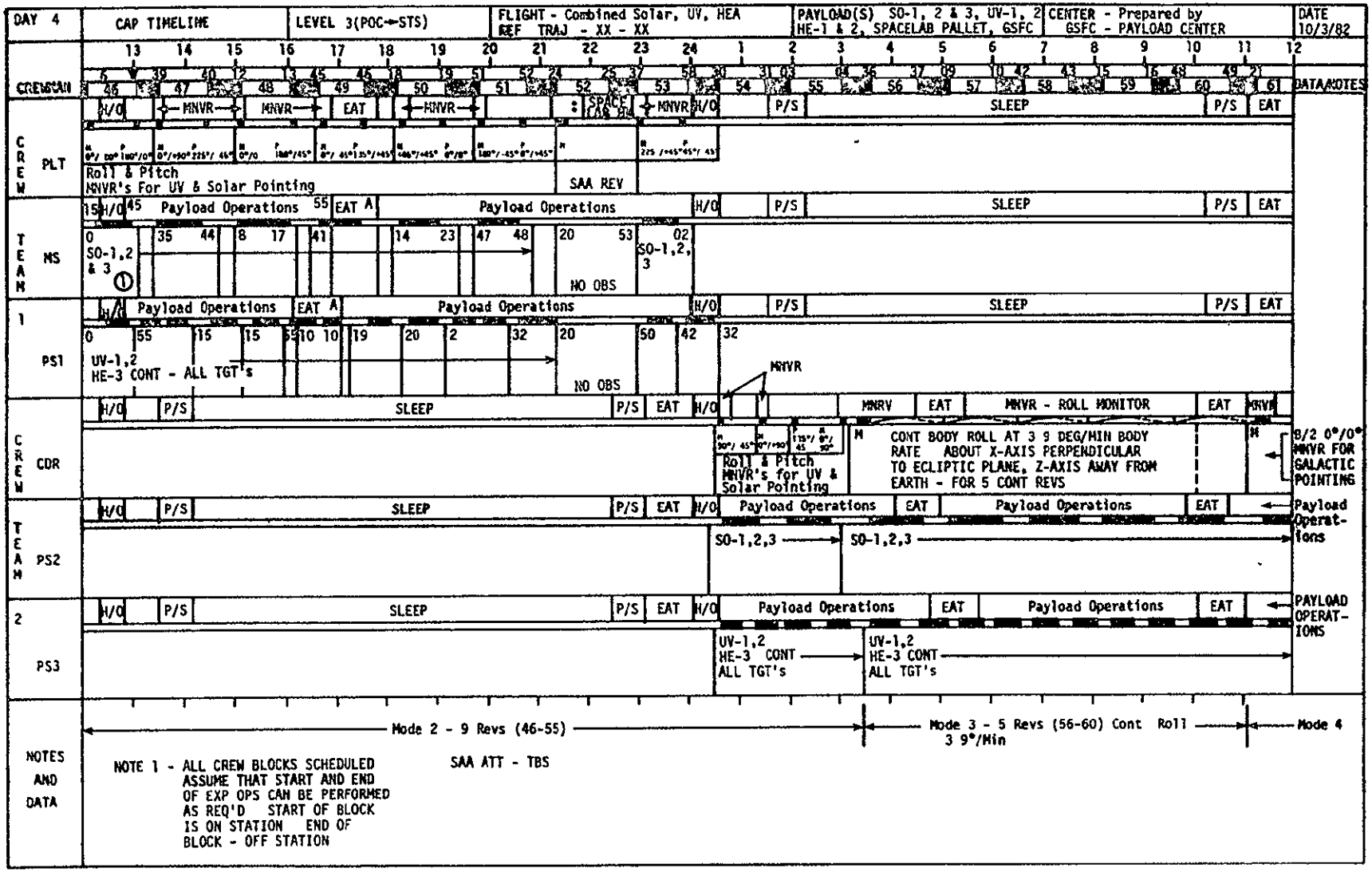


FIGURE 9 - CAP TIMELINE FORMAT (TYPICAL DATA)

(2) Activity Dependent events (e.g.)
Opportunities
Targets - "data takes"

(3) Payload Operations and Data
For integration - Time Blocks, Major Operations and data limited to Orbiter and Payload integration

The large space at the bottom of the form is for notes, associated planning data, etc., dependent on the specific flight. Associated time oriented subsystems operation, TDRS Acquisition, etc., are to be included in the companion CAP Profile Data form, unless specific portions of this data must be on this sheet.

Attached is a blank timeline form and a sample summary integrated timeline (Figures 8 and 9)

3.6.2 CREW ACTIVITY PLANNING (CAP) PROFILE DATA FORMAT

The Crew Activity Planning (CAP) Profile Data form is for CAP profile data plotting by the Payload Center and STS Operator for the purpose of integration. A blank form and one with typical data are presented in Figures 10 and 11, respectively.

This form design is similar to the CAP Timeline form and may be prepared at the same level of detail as the CAP Timeline (i.e., 8, 12, 16, 24 hour periods).

Each space allows plotting of one or more parameters depending on complexity of the data item and the space required. Data should be plotted against time in a manner which coincides with the CAP Timeline.

The Summary Level Profile Data will contain a majority of Payload Data needed for integration. The Profile data will potentially include the following parameter profiles:

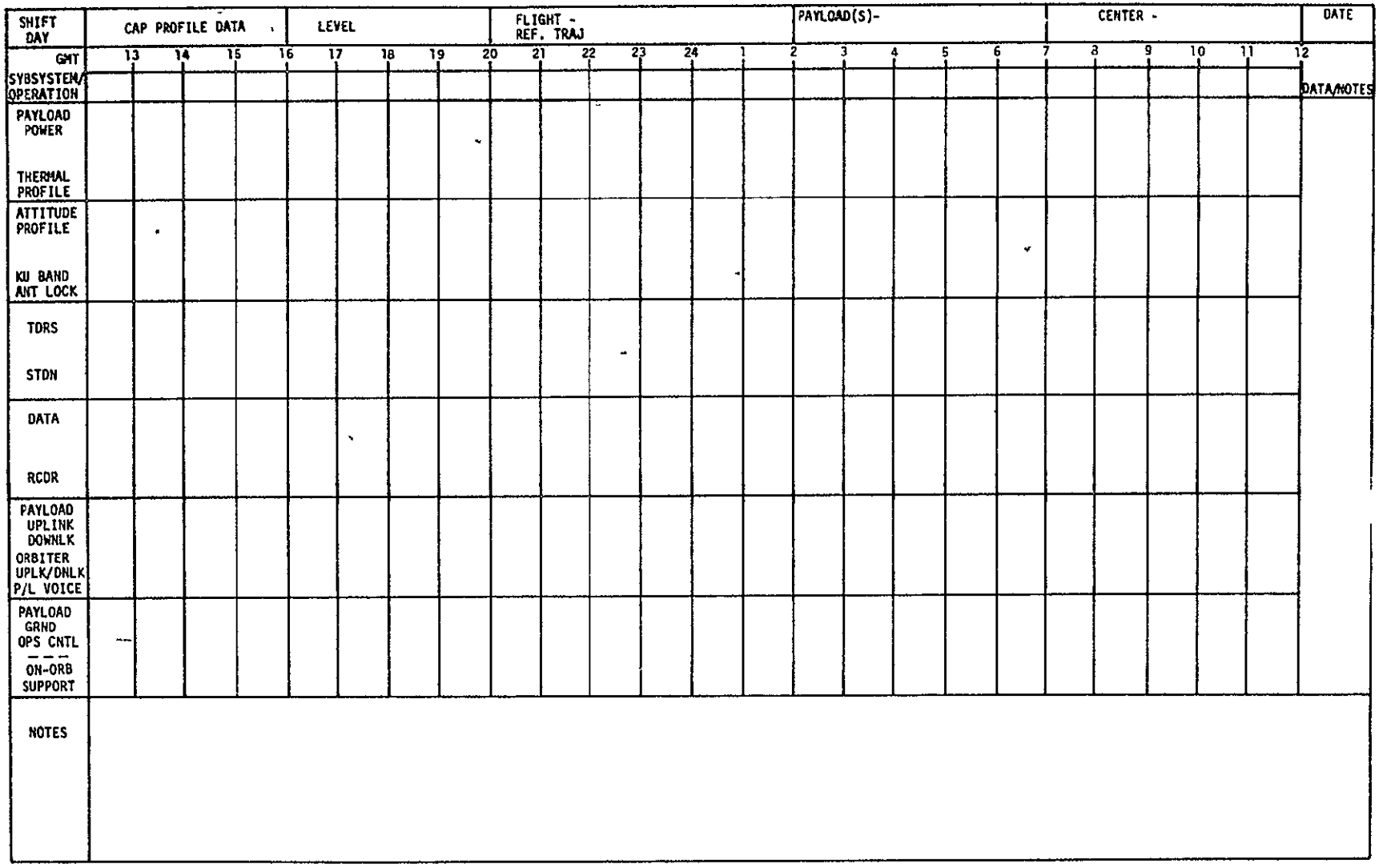


FIGURE 10 - CAP PROFILE DATA FORMAT

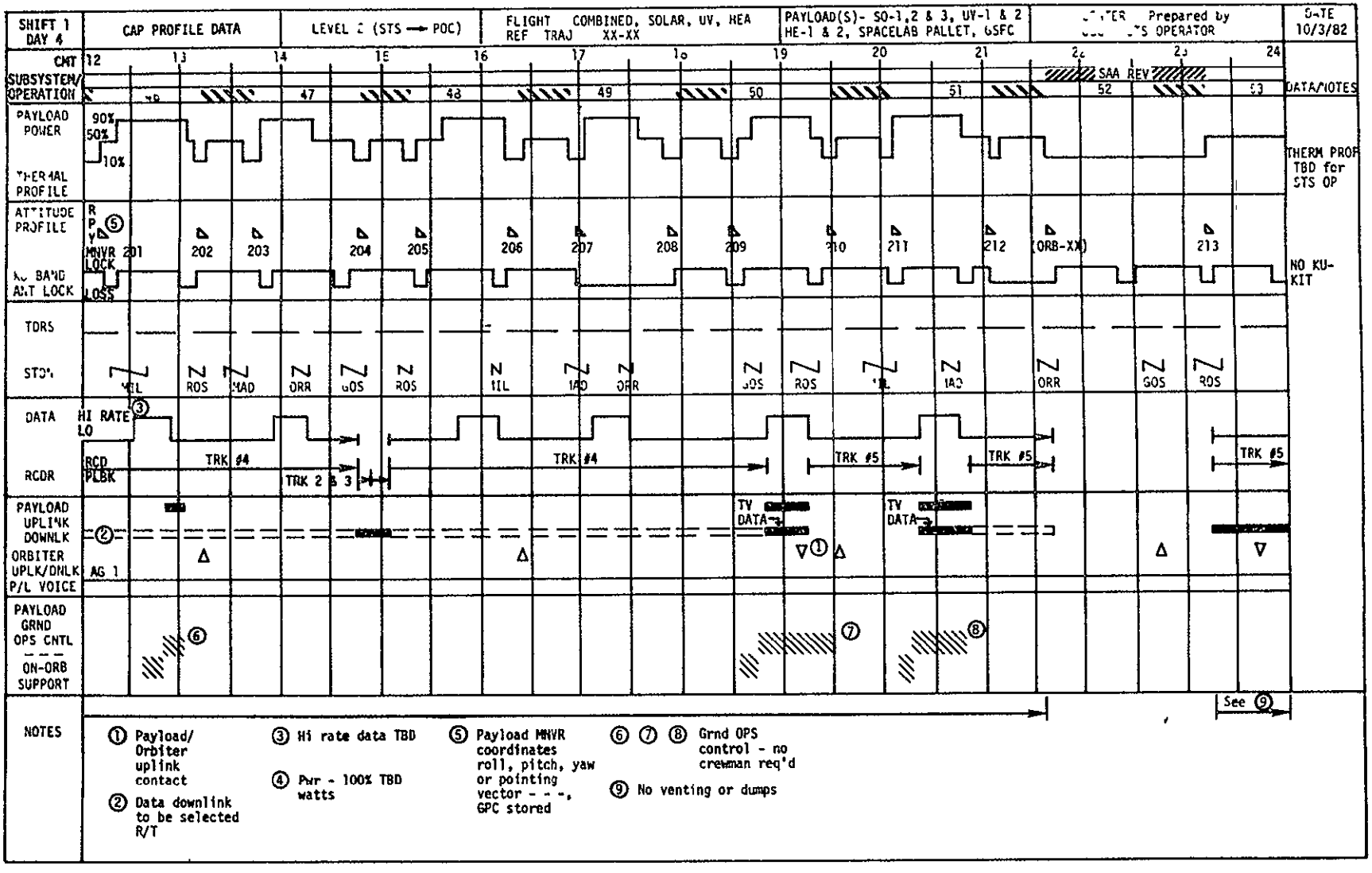


FIGURE 11 - CAP PROFILE DATA FORMAT (TYPICAL DATA)

Payload Power
Attitude Profile or Maneuvers
KU Band Acquisition Profile
TRDS (repeated)
STDN (repeated)
Data Profile (especially HI data rate periods)
Orbiter Recorder useage (Track vs Time)
Payload Data/TV/Voice - Uplink/Downlink
Payload Ground Control & Critical On-Orbit Support requirements
Venting/Dump prohibitions

3.6.3 SUPPLEMENTAL CAP DATA

The following CAP Payload Operations scheduling data forms should be used in addition to the summary timeline when an activity requires integration and:

- o Cannot be fully defined on a Summary timeline
- o Requires special Orbiter support or Orbiter crew requirements
- o Requires special coordination between the Payload and STS CAP planners
- o Conflicts with existing Orbiter timeline scheduling

The two forms are the:

(1) Payload Operations Scheduling data (Supplement to timeline scheduling) (Table I)

(2) Event Sequence/Chronology (Figure 12)

The events sequence/chronology form should only be required when complex or lengthy operations need further description. The form allows for sequences, operation identification, time for performance, assignment or crewman (i.e. both payload and

TABLE I

PAYLOAD OPERATION SCHEDULING DATA (Supplement to timeline scheduling)

PAYLOAD OPERATION _____ TIMELINE TITLE _____

EVENTS (Scheduling criteria & constraints)

ORBITAL REQUIREMENTS: SOLAR _____

STELLAR _____

OTHER _____

OPERATION TIME BLOCK: DURATION _____

CRITICAL TIME(S) _____

OTHER (Integrateable requirements) _____

CREW (scheduling criteria & constraints)

PAYLOAD CREW ASSIGNMENT: PS1 _____, PS2 _____, PS3 _____

ORBITAL CREW (Payload operations) ASSIGNMENT: CDR _____

PLT _____, MS _____

ORBITER VEHICLE SUPPORT REQUIREMENTS & CONSTRAINTS

ATTITUDE: ROLL _____, PITCH _____, YAW _____

ATTITUDE HOLD _____ RATE, TIME DURATION _____

COMM & DATA _____

CCTV & CAMERA USAGE: _____

ORBITER BAY LIGHTING _____

RMS _____

OTHER ORBITER SYSTEMS USAGE _____

_____

_____

_____

ORBITER OPERATION CONSTRAINTS: PROHIBIT VENTING _____

CREW OR VEHICLE MOTION _____

OTHER _____

_____

_____

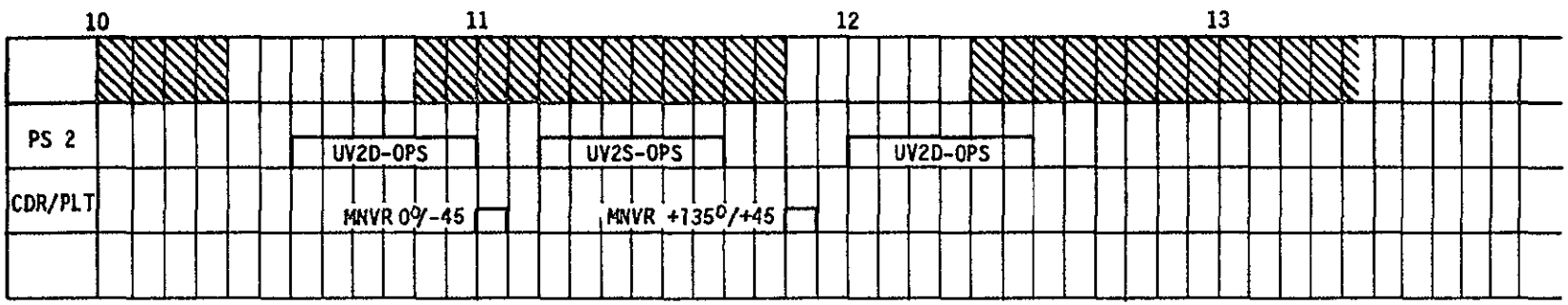
CREW ACTIVITY PLANNING — A

EQUIPMENT: GP UV Telescope

ACTIVITY/OPERATION: Dark & Solar Operations

FLIGHT APPLICABILITY — Combined UV, Solar, HE Sortie Mission 1

EVENT DESCRIPTION	PAYLOAD OPERATION			ORBITER OPERATION		
	Operation	Time	Crewman	Time	Operation	Crewman
Orbiter Maneuver				MAN-P	"XX"	CDR/PLT
Orbiter Stab & Wait Time		5^m				
UV-2 Operations	UV2D-OPS	30^m	PS 2			
Wait Time		10^m				
Orbiter Maneuver				MAN-M	"XX"	CDR/PLT
Orbiter Stab & Wait Time		5^m				
UV-2 Operations	UV2S-OPS					



CONSTRAINTS, CONSIDERATIONS, OPTIONS-

NOTE. Maneuver shown at approximate location only. Actual maneuver timing must be selected only after SO-1,2, & 3 experiment. Observation periods are also timelined.

FIGURE 12 - EVENT SEQUENCE/CHRONOLOGY

Orbiter crewman) listing and timelining for a given experiment/ investigation. The form also provides for notes, instructions associated scheduling constraints, consideration, options and additional scheduling criteria. This format is readily adaptable to automated data base operations for scheduling.

3.6.4 ORBITER/CREW SCHEDULING CRITERIA FORMAT

The Orbiter and Crew Scheduling Criteria form (Table II) contains the nominal Orbiter systems on-orbit functions and crew scheduling criteria. The associated Crew Work/Rest Schedule is to be used with these criteria. The Orbiter and Crew Scheduling Criteria should be identical, except for minor modifications or updates, for most flights. Therefore, once the Shuttle flights have stabilized and the normal initial fluctuations of the scheduling criteria have ceased, only minor updates and flight specific changes will be required.

The form contains the Orbiter or Crew event/activity, the reference title to be used on the CAP Timeline, the crewman assigned to the activity, the time and frequency for each activity, and the criteria for timelining the activities. The criteria will include nominal criteria, plus constraints for flight specific use, allowable variations, limits, cautions, etc.

3.6.5 SEVEN (7) DAY - FLIGHT ALLOCATION FORECAST - FORMAT

The 7 day Flight Allocation Forecast form (Figure 13) is to be prepared to identify the preliminary payload CAP allocation of objectives, requirements, and related data to a daily or periodic schedule. (Figure 14 presents typical data.)

Trajectory related events, opportunities, and targets, which require early identification and consideration for overall Payload/Orbiter and Crew planning should be emphasized for integration. This form is laid out for a 24-hour period. If greater

ORBITER/CREW SCHEDULING CRITERIA

NOTES: C = CDR; P = PLT; M = MSN SPEC
PS = P/L SPEC; ALL = CDR, PLT, M & PS

STS REQUIREMENTS	CMN	FREQUENCY	TIME	INSTRUCTIONS & NOTES
GENERAL				
EAT	ALL		1:00	3/day: includes prep & cleanup; scheduled simultaneously initial
SLEEP	ALL	1/24 HRS	8:00	
PRESLEEP	ALL	1/24 HRS	:45	
POSTSLEEP	ALL	1/24 HRS	:45	
HANDOVER	ALL	1/12 HRS	:30	For 2 shift operations only; twice a day
SPACELAB HK	C.P.M.	1/24 HRS	1:00	Activities req'd to maintain spacelab systems
WMC BIOCIDE	C.P.	1/48 HRS	:30	General cleaning of WMC with biocide wipes
LIOH CHANGEOUT (ORB)	C.P.M.	1/12 HRS	:05	Change 1 of 2 every 48 man hours
LIOH CHANGEOUT (S/L)	C.P.M.	1/24 HRS	:05	Frequency dependent on # of crewman & activity in S/L
FC PURGE (AUTO)	C.P.M.	1/8 HRS	:05	Possible attitude MNVR to point vent at sun
FC PURGE (MAN)	C.P.M.	1/8 HRS	:30	Allows for 2 min H2/O2 VIV OPS & HTR Management; att MNVR
EPS/ECLSS CK	C.P.M.	1/24 HRS	:10	Reading/recording of CRT and gauge readouts
AERO FLT CONT CK	C.P.		:05	Pre-entry activity
OMS/RCS CK	C.P.M.		:05	A pre-burn activity; additional data obtained in sts consum. ck
APU/HYD CK	C.P.		:05	Pre-entry activity
SCREEN CLEANING	C.P.M.	1/72 HRS	:15	
FC POWER UP	C.P.M.		:10	As required
FC POWER DOWN	C.P.M.		:05	As required

TABLE II ORBITER/CREW SCHEDULING CRITERIA FORMAT

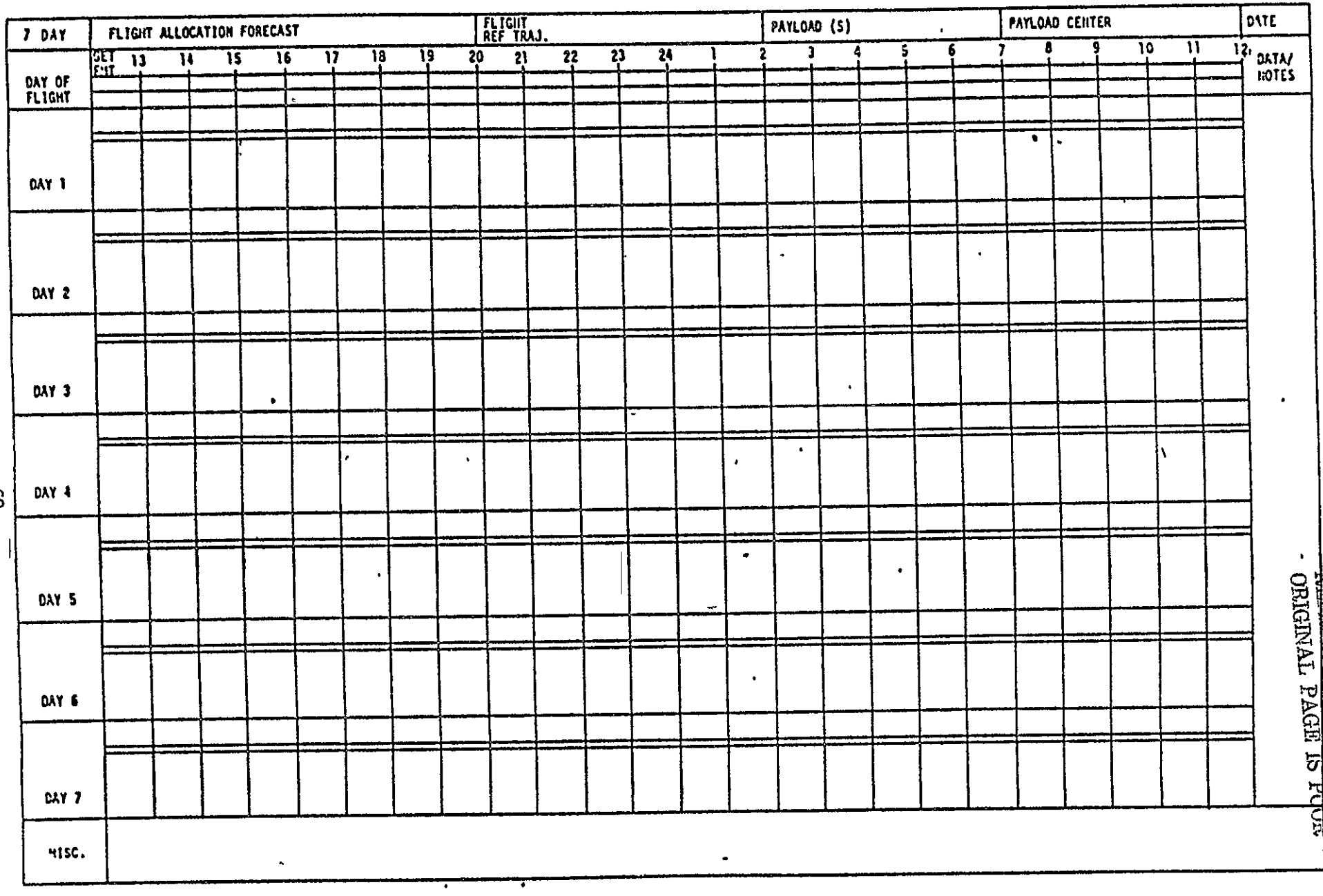


FIGURE 13 CAP ALLOCATION FORECAST FORMAT

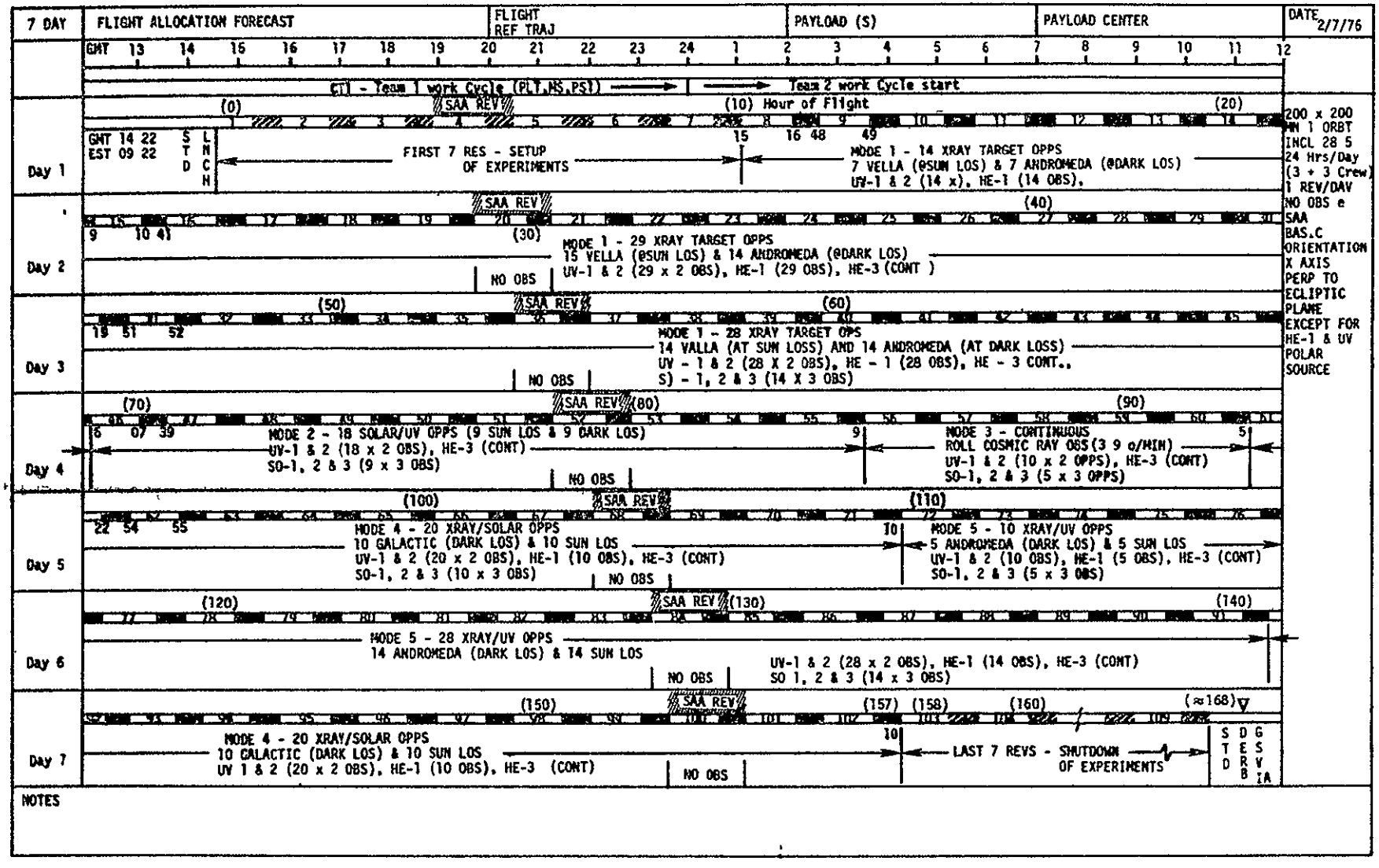


FIGURE 14 - CAP ALLOCATION FORECAST (TYPICAL DATA)

resolution is required, this form can be converted to a 12-hour period, using as many additional sheets as required.

This form will not normally be used except as an overview unless the Payload Center desires to show an overall planning picture or is requesting JSC to prepare the summary timelines for the Payload Center and supplies it as an initial input.

3.6.6 CREW WORK/REST SCHEDULE SUMMARY FORMAT

The Crew Work/Rest Schedule summary form is to be prepared for Payload and Orbiter CAP Summary Timeline integration. The completed form is a summary presentation of the total flight and requires fundamental agreement between the center(s) and the STS Operator before detailed planning can proceed. (Figures 15 and 16).

3.6.7 ONBOARD UPLINK FORMAT

The CAP uplink form comprises a combination of a crewman timeline and execute details for one operational duty shift.

This form replaces the two forms usually uplinked, the overview and detailed plans. The plan portion of the form gives an overall blocked schedule of one crewman's activities. The detailed portion of the form gives the details of operations times, and data and instructions for specific events.

This single uplink gives all the data for one crewman. A set can be correlated by the crewmen onboard as required. An additional "execute data" uplink may be required for complex inflight activities.

CREW WORK/REST SCHEDULE - Summary

FLIGHT :_____
REF. TRAJ.:_____
LAUNCH :_____ RETURN:_____

TEAM 1 ___,___,___ TEAM 2 ___,___,___

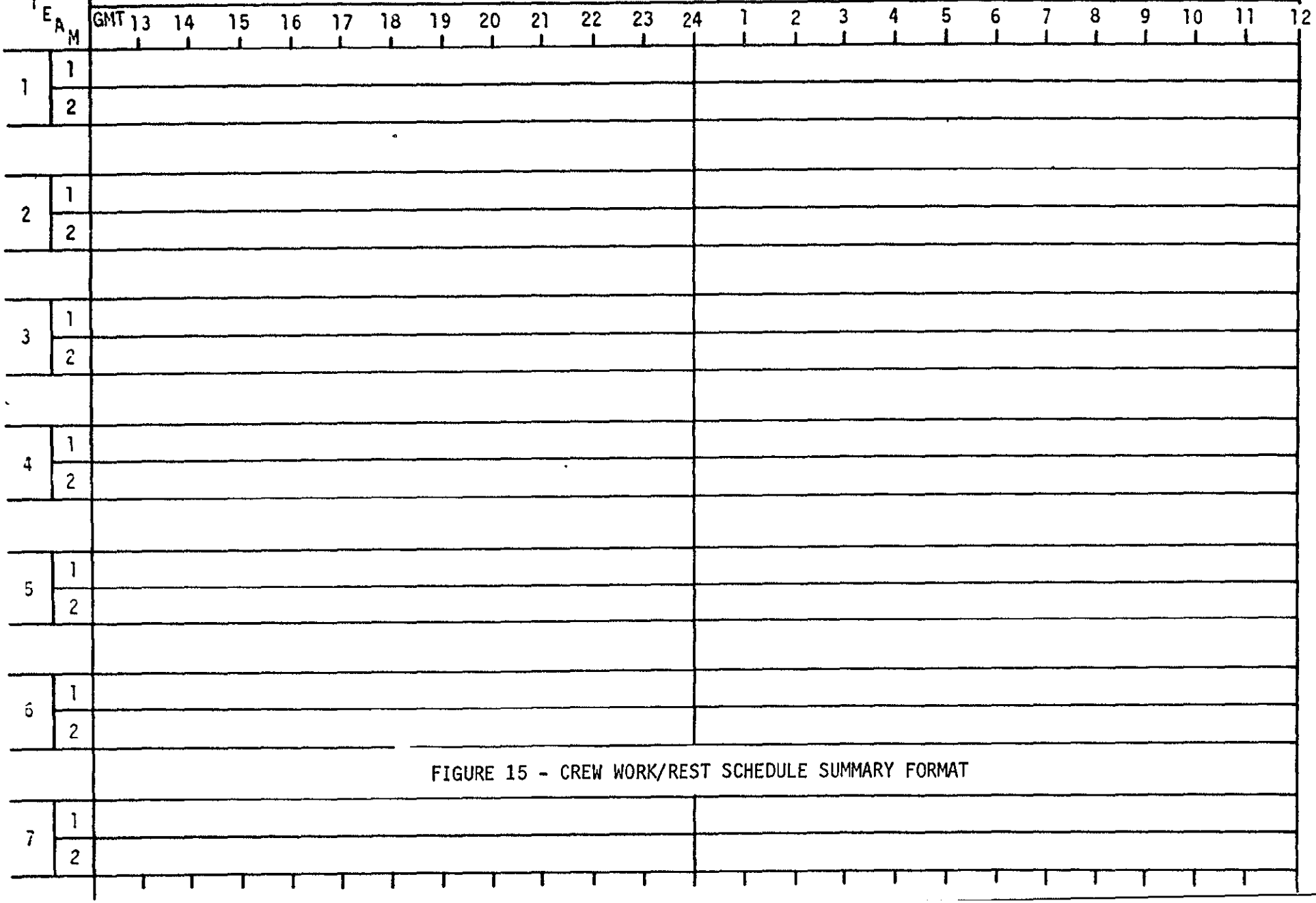


FIGURE 15 - CREW WORK/REST SCHEDULE SUMMARY FORMAT

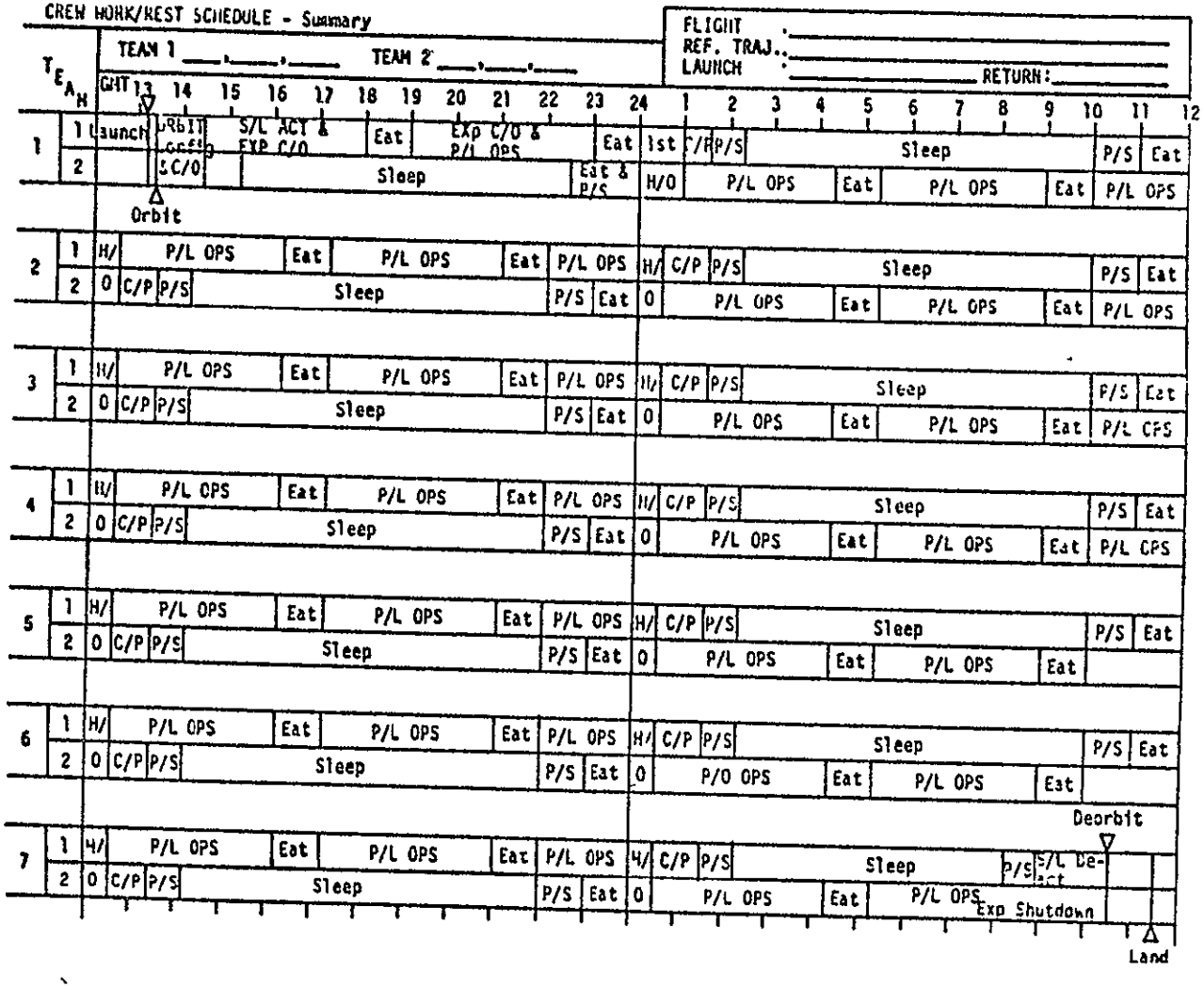


FIGURE 16 - CREW WORK/REST SCHEDULE SUMMARY (TYPICAL DATA)

UPLINK CAP "PLAN" (AND DETAILS)

CMN CDR DAY 1 SHIFT 2

NO. 501 REV. B

DATE 08/03/82

GMT	CAP	TIME	CMN DETAILS DATA/INSTRUCTIONS
22:00	SLEEP	--:--	
30		--:--	VEHICLE ATTITUDE
23:00	PS & EAT	--:--	R/90°, P/90°, Y/90°
		--:--	
		--:--	
24:00	H/O	24:00	HANDOVER TO CDR, MS, PS1
		--:--	
45		24:45	GRND CONF - MIL (12 MIN)
1:00	GRND CONF	--:--	
	ORB SYS OPS	--:--	
		--:--	
2:00		2:16	MNVR - R/180°, P/95°, Y/40°
		--:--	(3.2 MIN)
		--:--	
3:00	P/L SUP. (TO PS2 PS3)	--:--	
		--:--	
4:00		--:--	
		--:--	
45		4:45	MNVR - R/90°, P/90°, Y/90°
5:00		--:--	(3.2 MIN) THERMAL NOM
	EAT	--:--	
		--:--	
6:00		6:02	ORD OPS 32-10, GPC CODE
	ORB OPS	--:--	"EXC 3212" (10 MIN)
45		--:--	
7:00		--:--	MNVR - R/120°, P/90°, Y/60°
	P/L SUP	7:29	(3.0 MIN)
		--:--	
8:00	(TO PS2)	--:--	
		--:--	
		--:--	
9:00		8:50	MNVR - R/90°, P/90°, Y/90°
	ORB HK 610	--:--	(3.0 MIN) THERMAL MON
		--:--	
10:00		--:--	
	H/O REPORT PREP	--:--	
30		--:--	
11:00		--:--	
	EAT	--:--	
30		11:30	HANDOVER TO PLT, PS2, PS3
	H/O	--:--	
12:00		--:--	
	PS	--:--	
		--:--	
13:00		--:--	
30		--:--	
	SLEEP	--:--	
14:00		--:--	

FIGURE 17 - ONBOARD UPLINK FORMAT

3.7 REFERENCES

1) Shuttle Crew Activity Planning Techniques (Appendix G, Space Shuttle Crew Procedures Management Plan), September 5, JSC 0930.

2) Shuttle Payload Accommodations, Volume 14, JSC 07700.

3) STS OPERATIONS BOP (Baseline Operations Plan)

4) STS Payloads Mission Control Study (1975/76)

5) Phase of STS Preflight Planning (memo), November 1, 1976, by W. P. Gatlin CF3, JSC.

3.8 PAYLOADS REVIEWED

The documentation reviewed on payloads between July 1975 and October 1976 ranged from presentations to study reports, Level A and B documents, and Mission Analysis reports.

Since the prime purpose of the review was to evaluate the payload operations for development of CAP methods and the identification of generic data, the majority of the material was adequate. Where more detail was obtained, additional analysis was performed. Those payloads which were reviewed in greater detail are noted on the following list with an asterisk (*).

The following is the total list of payloads covered in varying degrees of detail by this study:

- Dedicated Solar Physics
- High Energy Astrophysics (A)
- High Energy Astrophysics (B)
- * Combined UV, Solar, HEA
- Dedicated UV Astronomy
- MTM Solar Physics
- Spacelab UV Optical Telescope
- Mult/Mission Modular Spacecraft
- * Technology Demonstration Satellite
- * Advanced Technology Lab
- Long Duration Exposure Facility
- Spacelab-Space Processing Magnetospheric
- * Atmospheric Plasmas in Space
- Large Space Telescope
- Spacelab + Pallet Mission 8
- * Interim Upper Stage
- * Life Sciences (Med) Spacelab
- Shuttle Infrared Telescope Facility
- Biology & Bio Med Spacelab

Vestibular Function Res. Highly Auto.
Earth Viewing Application Laboratory
Adaptive Multi-Phased Array (Pallet)
* Shuttle UV Stellar Spectrophotometer
Lunar & Planetary Imaging System
Far UV TV Experiment
Standard Magnet Payload
* UV Solar Spectral Irradiance
Deep UV Survey Instrument
* Deep Sky UV Survey Telescope