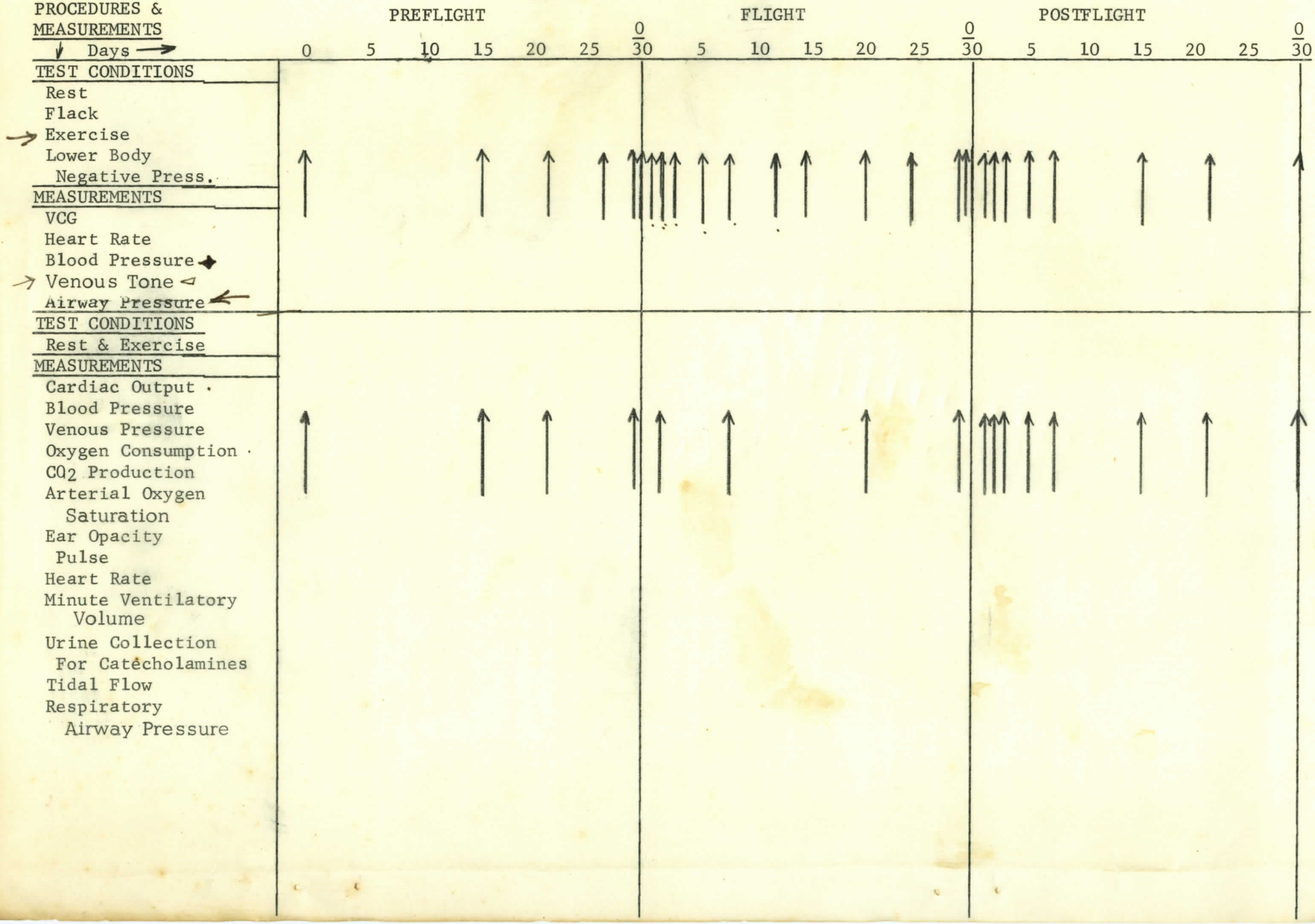
STATUS BRIEFING

U. S. AIR FORCE - MANNED ORBITING LABORATORY

BIOMEDICAL EXPERIMENT

JANUARY 1965

MOL BIOMEDICAL EXPERIMENT
STUDY OF CARDIOVASCULAR REGULATION



MOL BIOMEDICAL EXPERIMENT

STUDY OF CARDIOVASCULAR REGULATION

The chart opposite this page indicates the flight test conditions and measurements to be used for the study of cardiovascular effects of space flight. The indicated procedures are to be employed in all three phases of flight at the points in time indicated.

The provocative tests proposed will be quantified. The Flack will be held for 30 seconds at 40 mm. Hg airway pressure, exercise quantified by external work recording (wattmeter or tachometer), and lower body negative pressure by recording of pressure gradient. Use of the lower body negative pressure device inflight depends upon further development and testing.

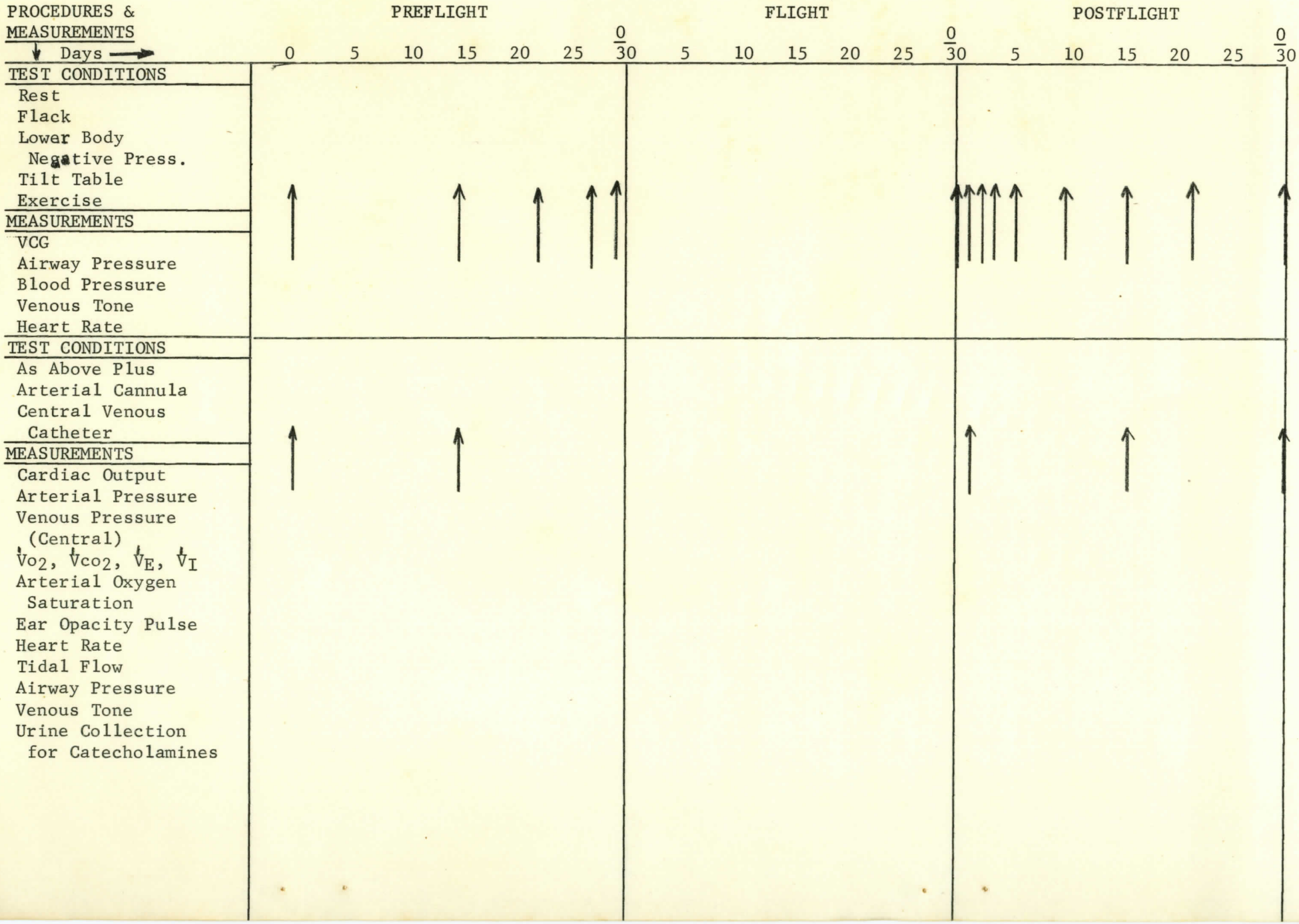
The use of exercise and lower body negative pressure as stress procedures in flight will not be particularly costly of time, since measurements would be made during an exposure to them programmed as daily physiological conditioning.

The heart rate will be continuously recorded during the programmed activities using R-R interval coding. VCG lead system will be the Frank. Systemic blood pressure will be obtained by a semi automatic Korotkoff sound system. Ventilatory flow and volumes will be recorded using a mass flowmeter or a high frequency waterless type spirometer. Cardiac output, oxygen saturation, and semiquantified ear opacity pulse will be obtained with a compensated three cell oximeter-densitometer earpiece. T-1824 dye will be employed. Gas composition of air samples will be measured with a mass spectometer or individual oxygen and CO_2 sensors.

The timing of the sequential studies has been scheduled to provide more frequent measurement at times when more rapid changes are likely to occur. More studies are scheduled in the post flight period for two reasons, (1) lesser likelihood of compromising total mission success and (2) an effort to detail the time course of recovery of the normal state. The flight studies are more frequent in the first few days of orbital flight which provides a better ability to assess adaptation to orbital flight conditions, and shortly before deorbit, which provides assurance about the crewmen's ability to tolerate reentry and recovery stresses as well as to provide more data regarding the state obtained immediately prior to the readaptation to the earth surface conditions.

MOL BIOMEDICAL EXPERIMENT

STUDY OF CARDIOVASCULAR REGULATION - CON'T.



MOL BIOMEDICAL EXPERIMENT

STUDY OF CARDIOVASCULAR REGULATION - CON'T

The opposing chart depicts the studies and time frame of crew measurements proposed to be done only in the preflight and postflight periods. It partially duplicates the previous chart. However, the tilt table will be used as an additional test condition in ground research.

In addition, five of the test periods (2 preflight and 3 postflight) will employ arterial cannulation and central venous catheterization by a percutaneous method. This provides for the addition of continuous arterial pressure recording and cuvette dye and oxygen saturation recordings. All of the other measurements will be made including ear piece data and cuff blood pressure. However, indocyanine green dye will be employed for indicator dilution curves to preclude the background dye problem produced with T-1824.

Sampling of arterial blood can also be accomplished at rest and with exercise for blood gas, hormone secretion and metabolite studies.

MOL BIOMEDICAL EXPERIMENT

QUESTIONS OF FEASIBILITY - CARDIOVASCULAR

ENGINEERING PROBLEMS

LOWER BODY NEGATIVE PRESSURE DEVICE

EAR OXIMETER-DENSITOMETER

MASS SPECTROMETER

ALTERNATIVE OR ADDITIONAL TECHNIQUES

INDIRECT FICK CARDIAC OUTPUT

INDOCYANINE GREEN CARDIAC OUTPUT

MOL BIOMEDICAL EXPERIMENT

QUESTIONS OF FEASIBILITY - CARDIOVASCULAR

ENGINEERING PROBLEMS

The development of a suitable device for the application of negative pressure to the lower body while in space flight depends upon the solution of several problems. These include the volume necessary for storage and use, the generation of a relative vacuum, and fabrication of an effective but comfortable waist seal. A collapsible, rigidized bellows may be an effective solution to the stored volume problem, but would require development of satisfactory stabilization while in use. If a space tap is employed for the vacuum source, the body seal effectiveness becomes critical for the control of space craft atmosphere leak. If a vacuum pump is used, power and weight penalties result; especially if the cabin atmosphere chosen is a low pressure high oxygen type. Industrial and in-house research and development is being accomplished to solve these and other problems.

A miniaturized ear piece optical density device must be developed to yield the ability to simultaneously detect changes in light transmission through the ear that may result from changes in blood content, oxygen saturation of blood, concentration of T-1824 dye and non-specific density effects. The major problem is that of coupling a single light path through the ear to three separate photo sensitive elements each of which is peaked to respond to a suitable light spectrum for independent detection of the various optical density changes mentioned. Other problems are those of calibration and analysis of the three output signals. Studies on two cell systems of this type at the Mayo clinic are very encouraging.

Rapid response gas analysis is desirable for measurement of end tidal O_2 and CO_2. Reports from the contracted MOL instrumentation study made by the Beckman Corporation are highly encouraging regarding the availability of a suitable mass spectrometer.

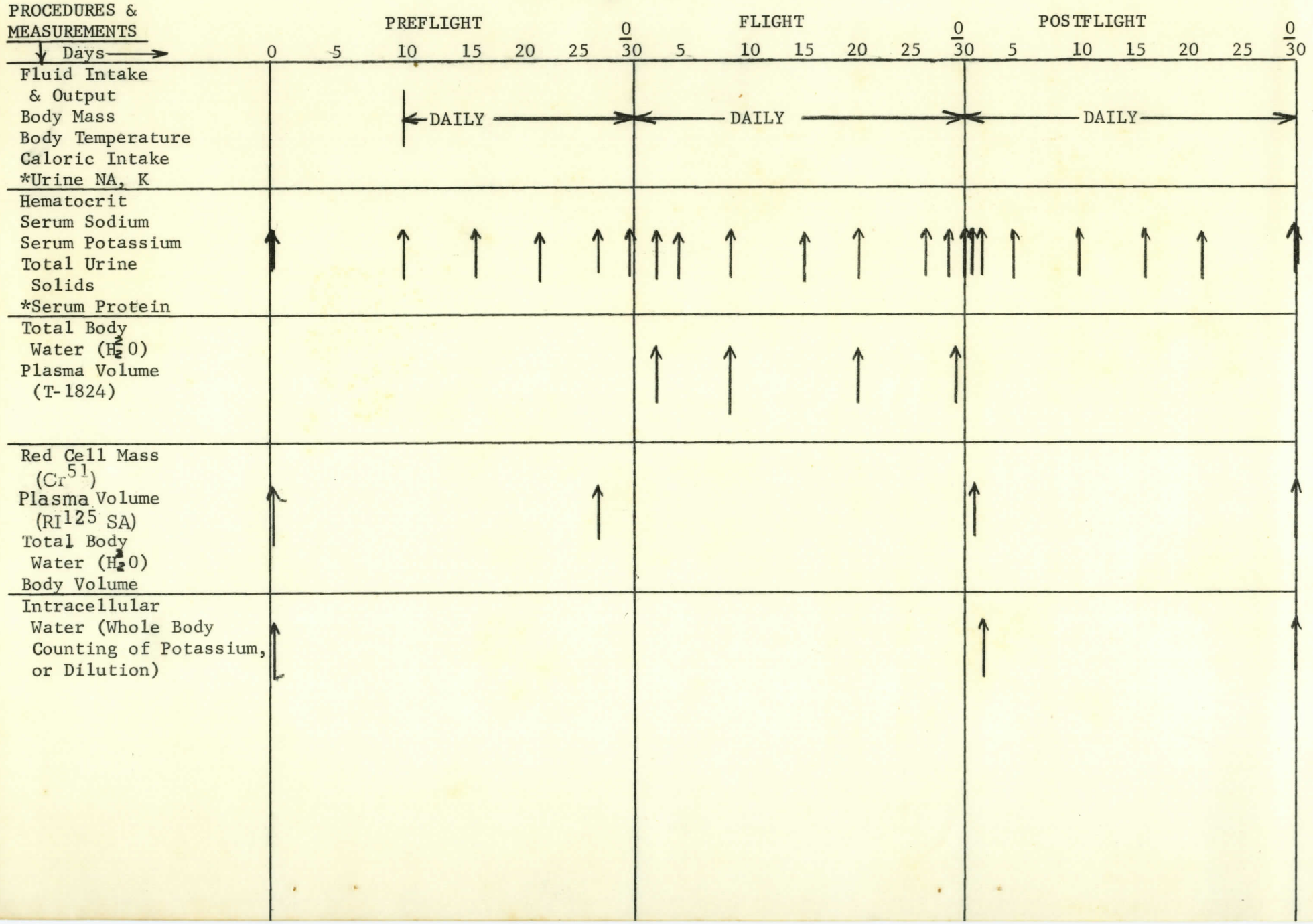
ALTERNATIVE OR ADDITIONAL TECHNIQUES

The possibility of using an indirect Fick cardiac output determination in lieu of the indicator dilution method is being studied. Further validation of the single breath CO_2 method described by Rahn is being accomplished in his laboratory and also at SAM.

Indocyanine green dye would afford great advantages over T-1824 dye, but cannot be used for plasma volume determinations.

MOL BIOMEDICAL EXPERIMENT

STUDY OF WATER & SOLUTE BALANCE & DISTRIBUTION



MOL BIOMEDICAL EXPERIMENTS

STUDY OF WATER & SOLUTE BALANCE AND DISTRIBUTION

This chart provides a matrix of the measurements proposed to be used to quantify water and solute balance and to assess changes in distribution within the body.

The daily urinary sodium and potassium measurements indicated in the first row will be accomplished for the flight period by the analysis of returned lyophilized samples. This is also the case for the periodic serum protein determinations indicated in the second row.

The T-1824 dye to be used for the plasma volume measurements inflight will be the same dose employed for the circulatory indicator dilution curves.

MOL BIOMEDICAL EXPERIMENT

QUESTIONS OF FEASIBILITY - WATER & SOLUTE

ENGINEERING PROBLEMS

BODY MASS MEASUREMENT

MASS SPECTROMETER

SPACE LYOPHILIZER

ALTERNATIVE OR ADDITIONAL TECHNIQUES

BODY VOLUME

ISOTOPIC BLOOD VOLUME DETERMINATION

MOL BIOMEDICAL EXPERIMENT

QUESTIONS OF FEASIBILITY - WATER AND SOLUTE

ENGINEERING PROBLEMS

The determination of body mass to the degree of accuracy necessary for value in assessing the time course of water loss will be difficult in weightlessness. A mathematical analysis of several possible techniques has been accomplished. The best possibility examined is that of measurement of the period of the damped oscillation of a beam rigidly attached to the laboratory structure. The measurement, made with the man encapsulated at the end of the beam, would be made at two beam lengths. The vibration frequency required would be low, less than 3 cps, to avoid resonance effects within the body. Problems in reproducing the center of mass in positioning the man may be encountered.

The use of a mass spectrometer for the measurement of deuterium oxide in urine or blood will be complicated by the need for separation of the water from the sample to avoid fouling the instrument.

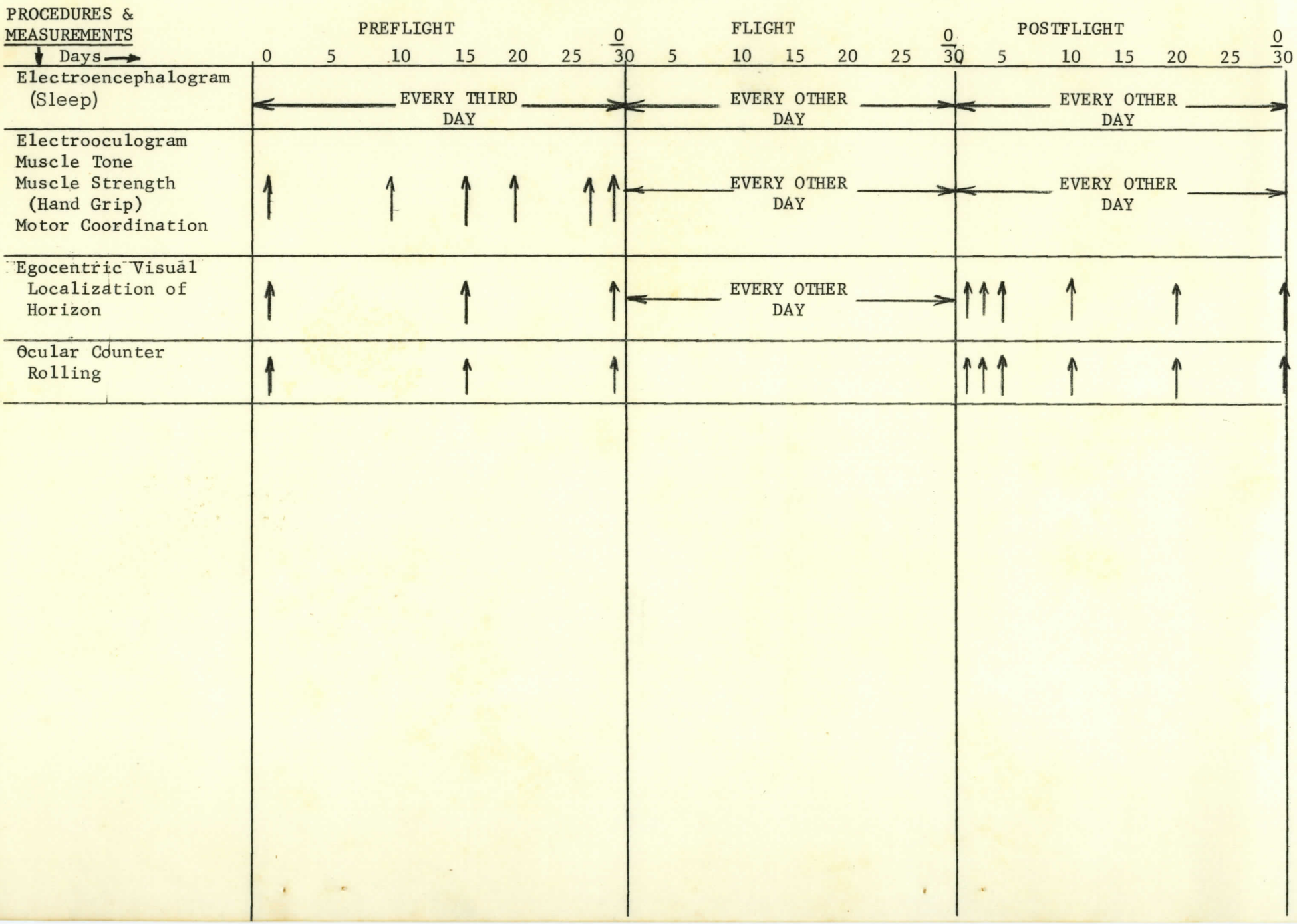
Engineering design of a lyophilizer for space use will depend upon the freezing and drying conditions required for preservation of substances in the plasma, urine and stool to be analyzed. These conditions are not known for all of the substances concerned. A sample packaging system must be incorporated. Again, the Beckman study indicates confidence that the requirements can be established and that the equipment can be available on the MOL schedule.

ALTERNATIVE OR ADDITIONAL TECHNIQUES

It might be possible to measure the total body volume by a plethysmographic approach provided an air lock of suitable size is available in the vehicle. The sudden addition of a known mass of gas into the lock with and without the man could yield volume measurement by difference in pressure change. Dilution of an added volume of inert gas might be another approach. Body density determination would then be possible if body mass is measured. This gives additional information about body composition.

Radioisotopic techniques of red cell and plasma volume measurement are more accurate than the T-1824 dye method. The studies proposed by NASA will be followed with great interest.

MOL BIOMEDICAL EXPERIMENT
STUDY OF CENTRAL NERVOUS FUNCTION



MOL BIOMEDICAL EXPERIMENT

QUESTIONS OF FEASIBILITY - NERVOUS FUNCTION

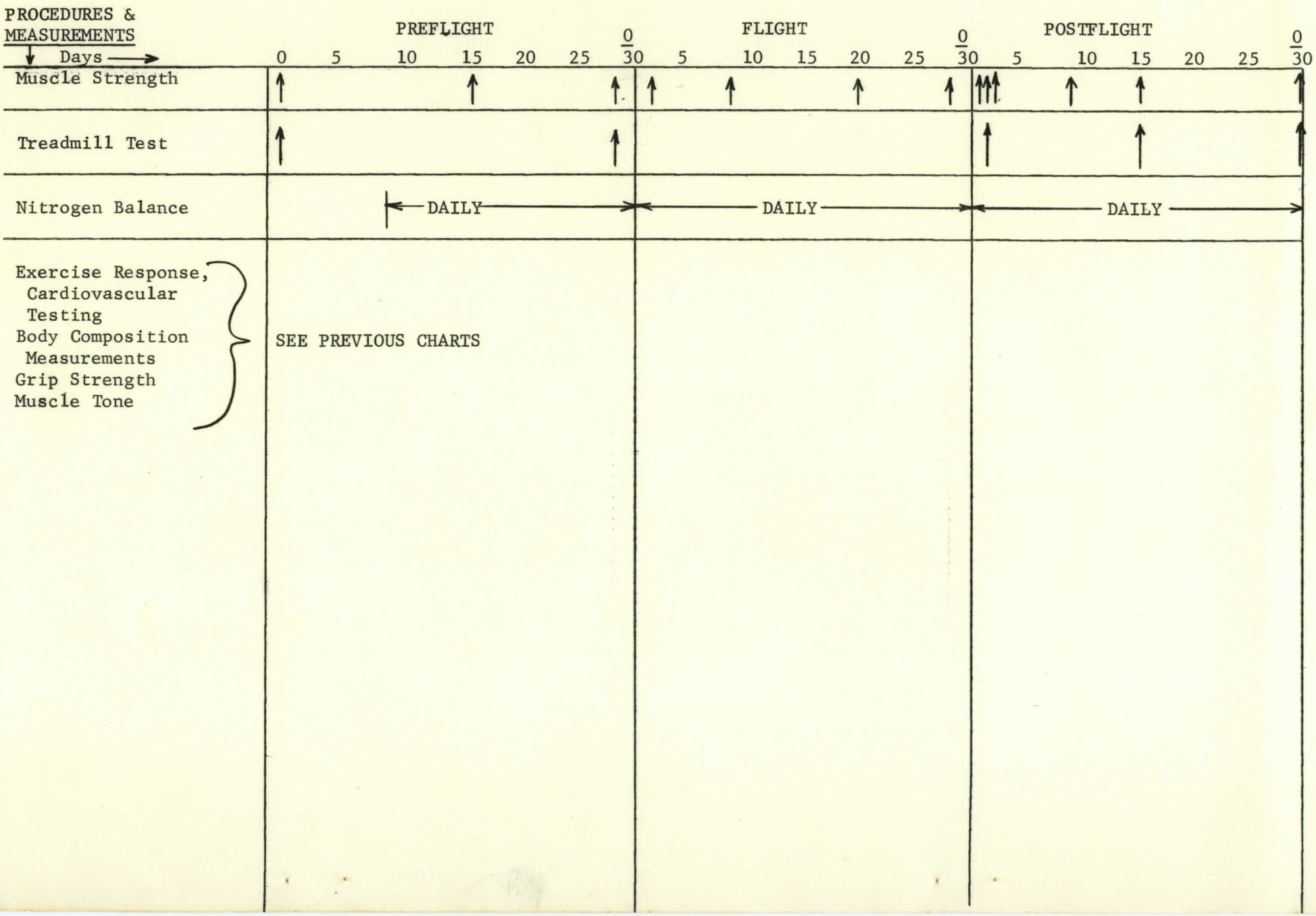
ENGINEERING PROBLEMS

EEG DATA VOLUME

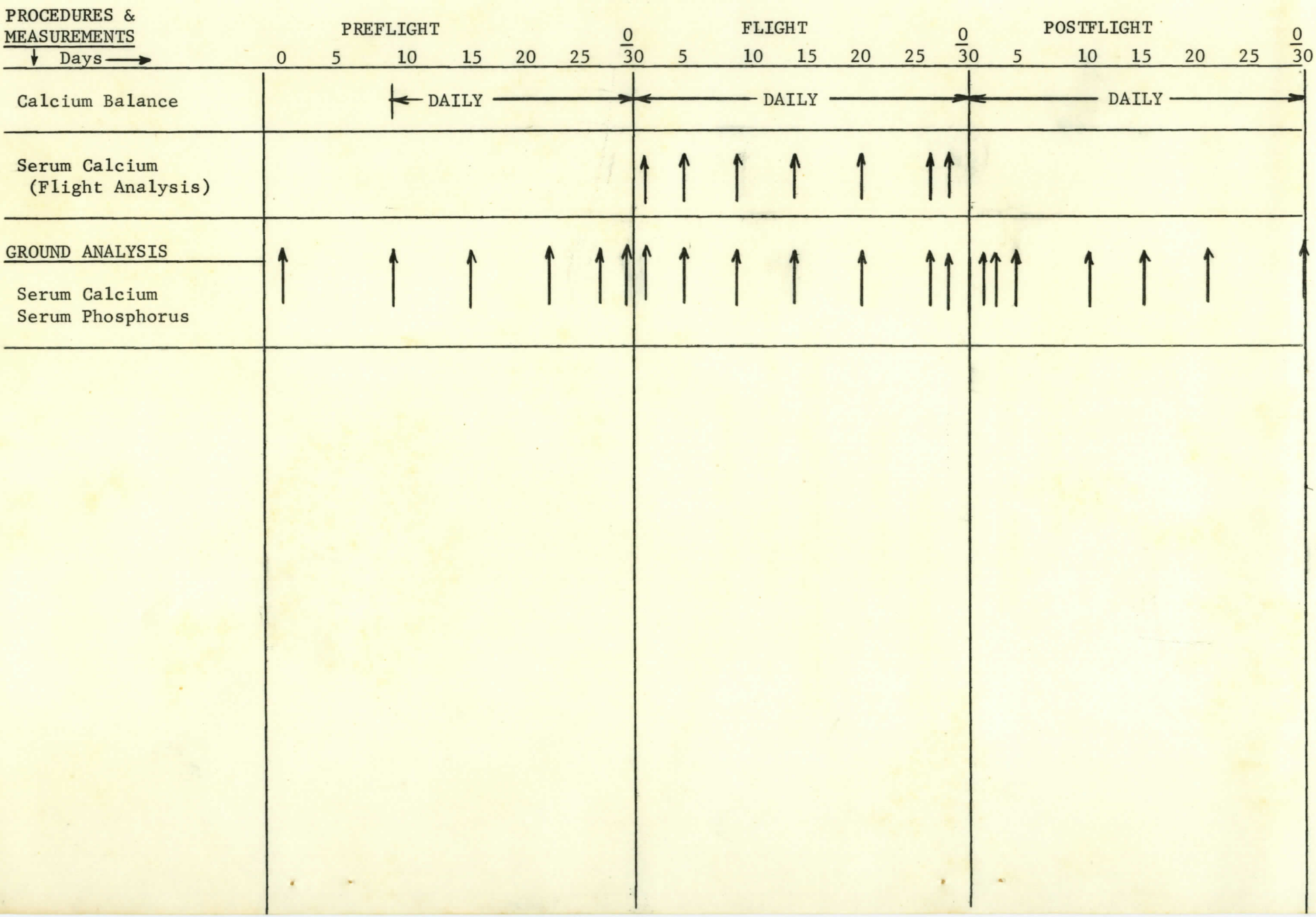
ALTERNATIVE OR ADDITIONAL TECHNIQUES

VENTILATORY RESPONSE TO CO_2 INHALATION

MOL BIOMEDICAL EXPERIMENT
STUDY OF MUSCLE STRENGTH AND WORK CAPACITY



MOL BIOMEDICAL EXPERIMENT
STUDY OF BONE MINERAL METABOLISM



MOL BIOMEDICAL EXPERIMENT

QUESTIONS OF FEASIBILITY - BONE MINERAL

ENGINEERING PROBLEMS

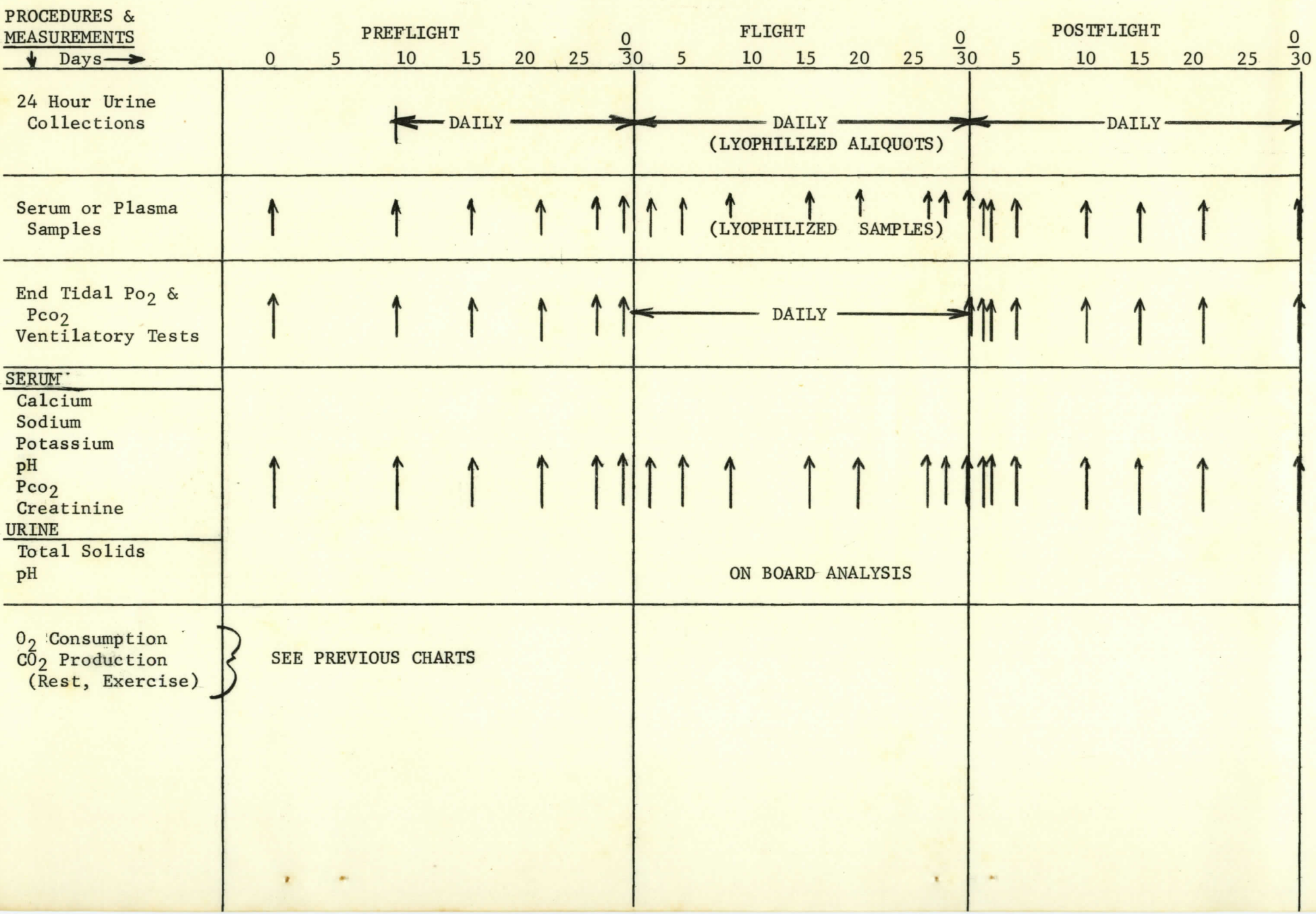
CALCIUM ANALYSIS

ALTERNATIVE OR ADDITIONAL TECHNIQUES

SWEAT COLLECTION OR ANALYSIS

Ca^{45} Cl INJECTION

MOL BIOMEDICAL EXPERIMENT
STUDY OF METABOLISM & ENDOCRINE FUNCTION



MOL BIOMEDICAL EXPERIMENT

QUESTIONS OF FEASIBILITY - METABOLISM

ADDITIONAL OR ALTERNATIVE TECHNIQUES

LABELED HORMONE INJECTION

PAROTID FLUID ANALYSIS

MOL BIOMEDICAL EXPERIMENT

QUESTIONS OF FEASIBILITY

GENERAL

FLIGHT CREW TIME REQUIREMENT

FLIGHT CREW RISK

PROCEDURAL COMPLEXITY

SYSTEM CONSTRAINTS