MEASUREMENT CAPABILITY OF IMBLMS PHASE B4

CLINICAL EVALUATION

HISTORY

PHYSICAL EXAMINATION

CARDIOVASCULAR MEASUREMENTS

ECG

VCG

PCG

VbCG

ZCG

CARDIAC OUTPUT

HEART RATE

BLOOD PRESSURE (ARTERIAL)

BLOOD PRESSURE (VENOUS)

PLETHYSMOGRAPHY (LIMB)

PULSE WAVE VELOCITY

PULSE WAVE CONTOUR

BALLISTOCARDIOGRAM

NEUROLOGICAL MEASUREMENTS

EEG

EMG

EOG

AGRAVIC PERCEPTION

OCULAR COUNTERROLLING

OCULOGYRAL ILLUSION

ANGULAR ACCEL THRESHOLD

VISUAL TASK w/HEAD ROTATION

CORIOLIS (MOTION) SICKNESS SUSCEPTIBILITY

METABOLIC MEASUREMENTS

EAR CANAL TEMPERATURE

O_2 CONSUMPTION, CO_2 PRODUCTION

AVERAGE SKIN TEMPERATURE

MUSCLE SIZE AND STRENGTH

BODY MASS AND SPECIMEN MASS

BALANCE STUDIES

MICROBIOLOGICAL MEASUREMENTS

BACTERIA/FUNGI

CULTURE/SENSITIVITY

STAIN

OBSERVE

IDENTIFY

TRANSMIT

PHOTOGRAPH

ENVIRONMENTAL MEASUREMENTS

PRESSURE

ATMOSPHERIC COMPOSITION

TEMPERATURE, HUMIDITY

SPACECRAFT MOTION

NOISE

RADIATION

MEASUREMENT CAPABILITY OF IMBLMS PHASE B4

RESPIRATORY MEASUREMENTS

RESPIRATORY RATE (RR)

VITAL CAPACITY (VC)

TIMED VITAL CAPACITY (VC_1, VC_3)

INSPIRATORY CAPACITY (IC)

EXPIRATORY RESERVE VOLUME (ERV)

TIDAL VOLUME (TV)

MINUTE TIDAL VOLUME (MTV)

MAXIMUM INSPIRATORY FLOW (MIF)

MAXIMUM EXPIRATORY FLOW (MEF)

MAXIMUM BREATHING CAPACITY (MBC)

ALVEOLAR pO_2

ALVEOLAR pCO_2

RESPIRATORY DEAD SPACE (V_D)

ALVEOLAR VENTILATION (V_A)

RESIDUAL VOLUME (V_R)

AIRWAY RESISTANCE (R_A)

LUNG COMPLIANCE

CARDIAC OUTPUT

O_2 CONSUMPTION

CO_2 PRODUCTION

DIFFUSING CAPACITY

MEASUREMENT CAPABILITY OF IMBLMS PHASE B4

LABORATORY ANALYSES

BLOOD

HEMOGLOBIN

HEMATOCRIT

pH

pCO_2

RBC COUNT

WBC COUNT

WBC DIFFERENTIAL

PLATELET ESTIMATION

RETICULOCYTES

RBC FRAGILITY

RBC MASS

BLEEDING TIME

CLOTTING TIME

RBC SURVIVAL

RBC MORPHOLOGY

CLOT RETRACTION

pO_2

PLASMA

SODIUM

POTASSIUM

CHLORIDE

CALCIUM

PROTEINS

GLUCOSE

PHOSPHATE

PLASMA VOLUME

SGOT

SGPT

ALKALINE PHOSPHATASE

BILIRUBIN

MISCELLANEOUS

TOTAL BODY WATER

URINE

COLOR

VOLUME

SPECIFIC GRAVITY

GLUCOSE

PROTEIN

BILE

pH

BLOOD

MICROSCOPIC

CALCIUM

PHOSPHATE

SODIUM

POTASSIUM

CHLORIDE

ACETONE BODIES

MEASUREMENT CAPABILITY OF IMBLMS PHASE B4

BEHAVIORAL MEASUREMENTS

SENSORY

VISION

- DEPTH PERCEPTION
- BRIGHTNESS THRESHOLDS
- VISUAL FIELD
- CRITICAL FLICKER FUSION
- PHORIAS
- ACUITY
- DARK ADAPTATION
- PHOTO STRESS
- COLOR PERCEPTION

AUDITORY

- PITCH DISCRIMINATION
- AUDITORY ABSOLUTE THRESHOLD
- AUDITORY TEMPORAL ACUITY
- SPEECH INTELLIGIBILITY

CUTANEOUS

- PRESSURE THRESHOLDS

PSYCHOMOTOR

- FINE MOTOR ABILITIES - STEADINESS
- COMPLEX MOTOR ABILITIES
- GROSS BODY COORDINATION
- CONTINUOUS CONTROL - TRACKING
- REACTION TIME (SIMPLE & COMPLEX)

COMPLEX

- TIME AND MOTION
- CONCENTRATION (PROBLEM SOLVING)

BII

ROUGH DRAFT

RECOMMENDED

ROUGH DRAFT

TEST	RATIONALE
CLINICAL CARDIOVASCULAR	
Hx and Px Forms	Keyboard punch coded data for all Hx and Px forms.
ECG (Frank)	Three channels to accommodate VCG active electrode and junction boxes Bioteletry receiver. Biotelemetry transmitters are GFE.
Phonocardiogram	GFE microphone, ECG preamp.
Cardiac Output	Kubicek impedance and rebreathing technique (using mass spectrometer below).
Thoracic Blood Flow	Doppler ultrasonic technique.
Blood Pressure	Manual and automatic with microphone, impedance or ultrasonic detector.
Venous Compliance	LBNP plus limb circumference using impedance or capacitance method.
Regional Blood Flow	Ultrasonic method, digital skin temperature.
Arteriolar Reactivity	Skin temperature; computer total resistance from C.O. and B.P.
Pulse Constant	As given by impedance, ultrasonic and capacitance methods.
PROVOCATIVE TESTS AND COUNTERMEASURES	
Response to In-Flight Exercise	Ergometer GFE; IMBLMS will support with sensors, cardiotachyometer, data management power.
Response to LBNP In-Flight	LBNP GFE; IMBLMS will support as under exercise including source of negative pressure.
CLINICAL RESPIRATORY EVALUATION	
Lung Capacities	Dry gas volume meter (M-19) and inflight bag (M-20).
Gas Flow Rate	Mass flow meter.
Pressure, Volume, Flow	Airway interruption technique for pressure-flow relations.

ROUGH DRAFT

ROUGH DRAFT

RECOMMENDED (Continued) ROUGH DRAFT

TEST	RATIONALE
CLINICAL RESPIRATORY EVALUATION (Continued)	
Distribution of Blood Flow and Gas in the Lungs	Single breath methods using mass spectrometer and ear oximeter.
O_2 and CO_2 in Inspired and Expired Air	Mass spectrometer and sampling system will measure pO_2, pCO_2, pN_2 and pH_2O.
Arterial Blood	Ear oximeter.
GENERAL METABOLISM AND NUTRITION EVALUATION	
O_2 Consumption	Equipment supplied under Respiration.
CO_2 Production	Equipment supplied under Respiration.
Caloric Intake	Logging of food eaten and food waste at feeding station. Specimen mass device in IMBLMS (GFE).
Body Mass	GFE.
Lean Body Mass	Skin fold thickness and nomograph.
THERMAL REGULATION EVALUATION	
Core and Skin Temperatures	Thermistor harness and external auditory meatus.
CLINICAL NEUROLOGICAL EVALUATION	
Ocular Counterrolling	IMBLMS will supply cinematography capability and EOG. Balance of equipment is GFE per M053.
Oculogravic Illusion	IMBLMS will supply storage for Otolithic Test Goggles. Rod/Sphere Device and other miscellaneous devices per M053.
Threshholds of Linear Accelerations to Head	IMBLMS supplies data management.
SEMICIRCULAR CANAL EVALUATION	
Oculogyric Illusion	Cinematography and EOG provided.
Visual Task Performance with Head Rotation	Could use sequence of tasks related to IMBLMS consoles.

ROUGH DRAFT

RECOMMENDED (Continued)

TEST	RATIONALE
SEMICIRCULAR CANAL EVALUATION (Continued)	
Nystagmogram	EOG included in IMBLMS.
Eye Movement Animatography (with fiber optics bundle)	IMBLMS supplies animatography; fiber optics GFE.
Human Otolith Function (M-9)	Otolith test goggle could be incorporated in Orthorator.
Cerebral Electrical Activity (EEG)	IMBLMS will supply 9 electrode pairs with terminals at sleep and wash station. No provision for special work station but stimulus material provided under visual and auditory function below. Data compression (spectral analysis) still under study.

ROUGH DRAFT

RECOMMENDED

TEST	RATIONALE
BLOOD, PLASMA OR SERUM	
Calcium ✓	Calcium levels of blood important to coagulation, reflects skeletal status in zero-G with possible losses and is indicative of several pathological conditions of endocrine glands and kidney.
Hemoglobin ✓	Levels of hemoglobin in blood are indicative of a number of pathological conditions which might seriously impair the health of astronauts.
Hematocrit ✓	Hematocrit values indicate pathological conditions as well as being necessary for other measurements such as plasma volume and red cell mass.
Potassium ✓	Potassium levels are of key importance to astronaut electrolyte balance. Significant changes are produced by such pathological conditions as uremia and adrenocortical hyperfunction.
Sodium ✓	Sodium levels are of key importance to astronaut electrolyte balance.
Clotting Time	Yields an estimate of the functional integrity of the coagulation system of blood. Essential to hemostasis in response to wound trauma, etc., which may be decreased in such conditions as radiation damage.
Plasma Volume ✓	Significant changes in this parameter have been noted in pre- vs. post-flight measurements in Gemini flights.
RBC Cell Mass ✓	Same as Plasma Volume.
RBC Survival ✓	May provide mechanism of changes observed in RBC cell mass
WBC Differential	Yields information concerning leukocyte integrity in response to spaceflight as well as indicating a variety of pathological conditions such as radiation damage which are reflected by changes in proportions of the various white blood cells.
Blood Volume	Same as Plasma Volume.

ROUGH DRAFT

RECOMMENDED (Cont.)

TEST	RATIONALE
URINE (Cont.)	
Specific Gravity	Measures concentrating ability of kidney. Changes produced by kidney malfunction dehydration and other pathological conditions.
Turbidity	Yields a rough measure of particulate excretion in the genito-urinary tract such as bacteria, casts, red and white blood cells, etc.
Sodium	See Blood Sodium.
Chloride	See Blood Chloride.
Creatine	Indicator of muscular status evaluation as well as disease states such as fever.
FECES	
Calcium	See Blood Calcium.
Sodium	See Blood Sodium.
Potassium	See Blood Potassium.
Chloride	Important in estimating electrolyte balance. Changes produced by increased or decreased ingestion of chloride, vomiting and diarrhea.
Color	A gross measure of liver function and of diet. Intestinal or stomach hemorrhage such as that produced by radiation is also detectable by stool color.

ROUGH DRAFT

RECOMMENDED (Cont.)

TEST	RATIONALE
BLOOD, PLASMA OR SERUM (Cont.)	
Bilirubin	Levels are indicative of a variety of pathological conditions.
Chloride	Important to astronaut electrolyte balance. Changes produced by a number of pathological conditions.
Phosphorus (Inorganic)	Indicator of skeletal status evaluation. Changes observed in a number of pathological states.
Karyotyping	Means of observing chromosomal abnormalities produced by spaceflight and/or radiation.
WBC (Total)	Changes occur in disease states. Radiation can also induce acute leucopenia.
or some method of Thyroid eval. Protein-Bound Iodine	Indicator of thyroid function. Important to energy metabolism which may be changed by zero-G.
Bleeding Time o-Grg	Although poorly quantitative, this test yields an estimate of the functional status of the blood coagulation system. Indirect measure of radiation damage.
URINE	
Calcium	See Blood Calcium.
Creatinine	Yields a measure of muscular status evaluation in the face of zero-G conditions. Levels may also reflect muscle atrophy and other disease processes.
Potassium	See Blood Potassium.
Phosphorus (Inorganic)	Reflects skeletal status evaluation in zero-G. Levels are also indicative of a variety of pathological conditions
Urine Volume	Essential to determination of water balance. Retention or diuresis produced by zero-G or pathological conditions will be reflected by urine volume.
Hydroxyproline PIP	

ROUGH DRAFT

ROUGH DRAFT

RECOMMENDED IF SPECIFIC NEED

TEST	RATIONALE
CLINICAL CARDIOVASCULAR	
Ballistocardiogram	Should be separate GFE experiment. Biotelemetry receiver and calibration services in IMBLMS.
Peripheral	Superficial vein collapse method (Biosystems).
Diffusion	Radioactive CO for use with mass spectrometer below.
Toxic Contaminants	Could be included by selection of mass spectrometer with proper range. May be important in data interpretation.
PROVOCATIVE TESTS AND COUNTERMEASURES	
Response to Thermal Change	Internal heat stress by exercise; external heat stress by local heating for sweat collection.
Response to Carotid Artery Stimulation	IMBLMS can accommodate but little evidence favoring adaptation of reflex.
Response to Occlusive Cuffs	Intensive inflation cycle and multiple cuffs apparently required.
Response to Elastic Leotard	Can be tested by LBNP.
GENERAL METABOLISM AND NUTRITION EVALUATION	
Body Volume	Inflatable plastic bag and He dilution of questionable precision and accuracy.
THERMAL RECULATION EVALUATION	
Comfort Index	Thermal environment assessment not included in IMBLMS.
GASTROINTESTINAL ACTIVITY EVALUATION	
Gastric Motility	GFE endoradiosonde IMBLMS will have compatible biotelemetry receiver.
pH	As above with endoradiosonde.

ROUGH DRAFT

ROUGH DRAFT

RECOMMENDED IF SPECIFIC NEED (Cont.)

TEST	RATIONALE
URINE (Cont.)	
17-Ketosteroids	Indicator of testicular and adrenal cortical androgen secretion. Analysis is difficult and moderately large urine volumes required. Androgen secretion may be affected by radiation damage.
Proteins (Total)	Indicator of proteinuria, renal damage (as in the case of radiation), abnormal serum proteins and hypertension.
Ca^{45}	See Blood Ca^{45}
FECES	
Total N	Increases occur during tissue breakdown such as that produced by radiation.
BLOOD, PLASMA OR SERUM	
Ca^{45}	For Ca turnover and excretion measurements.
Platelet Adhesiveness	Measures functional ability of platelets to initiate clotting; not a quantitative test, but may be of some use if crew subjected to high radiation levels.
Thyroxine	Post flight analyses may be of interest if detailed stress studies done.
WBC Motility and Phagocytic Activity	Measures "healthiness" of polymorphonuclear leucocytes; more subjective than quantitative, may aid in assessing radiation effects.
Zinc	Essential for carbonic anhydrase activity; if special study performed, Zn levels may be of interest.
BEI	Although redundant if PBI performed, of interest if special thyroid and/or metabolic studies performed.
Spermatozoa	Collection may have therapeutic merit.

ROUGH DRAFT

RECOMMENDED IF SPECIFIC NEED (Cont.)

TEST	RATIONALE
URINE (Cont.)	
Indican	Measure of indole production from protein breakdown such as that produced by radiation.
pH	Indicator of acid-base balance.
Color	Indicator of some pathological conditions.
Urea Nitrogen	Changes in levels indicate a number of disease states including tissue breakdown as the result of radiation.
Protein-Albumin	Increases in urine albumin occur as a result of excessive muscle activity, fever and kidney disease.
Protein-Mucin	Changes occur as a result of irritation of the urinary tract.
Acetone Bodies	Increase as a result of abnormal catabolism of fats.
Antidiuretic Hormone (ADH, Vasopressin)	Reflects physiological responses to changes in the osmotic pressure of blood resulting from such states as dehydration, diabetes insipidus.
Microscopy	Examines urine for casts calculi, bacteria, cells, etc., indicating renal disease, stasis, infection, inflammation, etc.
Amino Acids	Indicates abnormal metabolism and leukemia. Former may occur in zero-G of spaceflight.
17-OH-Corticosteroids	Indicator of adrenal cortical activity which may be altered by the stress of spaceflight and/or radiation damage. Large volume of urine required.
Aldosterone Tetrahydroaldosterone	Extremely complex measurement procedure required. Important to electrolyte balance (sodium excretion).
Serotonin (5-HIAA)	A measure of neurohumeral activity. Large urine volumes and complex measurement procedure required.

ROUGH DRAFT

RECOMMENDED IF SPECIFIC NEED

TEST	RATIONALE
BLOOD, PLASMA OR SERUM	
Glucose	Yields information relative to the functional integrity of the pancreas. May change due to stress such as that produced by spaceflight and zero-G.
Proteins-Total	Indicative of dehydration and other pathological conditions.
Protein Fractions	May reflect changes in proportions of proteins in different fractions produced by spaceflight and zero-G. Also indicative of pathological conditions.
Creatine	Indicator of muscular status evaluation. Also shows changes in pathological states.
Creatinine	See Creatine.
Cholesterol Cholesterol Esters	Changes in blood levels are indicators of a number of pathological conditions. Changes may also occur in response to zero-G.
BUN	Changes produced by a number of diseases, including tissue breakdown such as that resulting from radiation.
Lactic Dehydrogenese	Significant changes in blood levels are produced by serious pathological conditions such as myocardial infraction. Not expected to occur in healthy astronauts.
Bicarbonate	Important to acid-base balance.
Fat Tolerance	Changes in response to stress. Also altered in cases of defective fat metabolism.
Fibrinogen	Essential clotting factor. Indicator of some pathological conditions including intravascular coagulation.
Methemoglobin	Increase in levels produced by a variety of chemical poisons.
Mucoproteins and Related Biocolloids	Changes are produced by massive breakdown of organic bone matrix.
Prothrombin Activity	One of the essential clotting factors of blood. Changes occur in several disease states.
Lipids	Changes are produced by increased fat intake, mobilization or failure to clear fats.

ROUGH DRAFT

ROUGH DRAFT

RECOMMENDED IF SPECIFIC NEED (Cont.)

TEST	RATIONALE
BLOOD, PLASMA OR SERUM (Cont.)	
Mg	Changes occur in malfunction of the parathyroid and tetany. Parathyroid function of interest in zero-G.
Alkaline Phosphatase	Indicator of liver function and osteomalacia.
Phospholipids	Changes occur in serum levels in cases of pancreatic hypofunction, kidney disease and anemia.
Lactate-Pyruvate	Indicators of muscle activity; important in muscular status evaluation.
α-Amino Nitrogen	Changes occur in cases of liver damage such as that occurring in response to radiation.
Immunoglobulins Immune Bodies	Indicate changes in antibody levels in response to the isolation of spaceflight.
Non-Protein Nitrogen	Indicator of protein catabolism, fever, stress, liver damage, etc. Some of which may occur as a consequence of radiation damage.
Platelet Count (Estimate)	Indicator of thrombocytopenia such as that arising from radiation damage.
RBC (Total)	Supplementary method to hemoglobin and hematocrit in diagnosing blood dyscrasias such as polycythemia and anemia (the latter may be a response to increased pO_2).
Reticulocyte Count	Indicator of the activity of hemopoetic tissue which may change in various conditions including those arising from decreased pO_2 (as at high altitudes) and radiation damage.
URINE	
Urobilinogen	Indicator of a number of disease states.
Hydroxyproline	Increased levels indicate dissolution of the organic matrix of bone, one of the possibilities which may be produced by zero-G.

ROUGH DRAFT

RECOMMENDED IF SPECIFIC NEED (Cont.)

TEST	RATIONALE
URINE	
Catecholamines P+P	Of definite interest in stress studies.
Mucoproteins and Related Biocolloids	Of particular interest in bone dissolution assessment.
FECES	
Cr^{51}	Of interest if routes of RBC and hemoglobin loss to be studied.

ROUGH DRAFT

NOT RECOMMENDED

TEST	RATIONALE
BLOOD, PLASMA OR SERUM	
Amylase	Significant changes occur only in the presence of certain severe diseases.
Lipase	See Amylase
Uric Acid	Only changes in severe disease states.
Serum Glutamic Oxaloacetic Transaminase	See Amylase
Serum Glutamic Pyruvic Transaminase	See Amylase
Iron	Significant changes occur only in cases of iron poisoning, aplastic anemia and hemolytic anemia. Other measurements give same information.
Fatty Acids	Indicates certain pathological conditions which can be diagnosed by other tests. Difficult to perform, requires large samples of specially treated plasma.
Clot Retraction Time	A test which must be done on-board immediately after withdrawal of whole blood. Would be a complicated procedure requiring centrifugation over long periods of time. Measurements are subject to large errors.
RBC Fragility	Changes occur only in extreme blood abnormalities, unlikely to occur in healthy adults.
Acid-Base Balance	Requires several measurements of input and output of acid and base. Complicated, difficult, and unlikely to change in healthy adults.
Liver Function Tests	Requires several measurements, large samples of serum and urine. Complicated, difficult, and unlikely to change in healthy adults except in response to severe radiation damage. In this event, however, other simpler tests will indicate this.

ROUGH DRAFT

ROUGH DRAFT

NOT RECOMMENDED

TEST	RATIONALE
BLOOD, PLASMA OR SERUM	
5-Nucleotidase AMPase ATPase	Of limited interest
Parathyroid peptides	Requires large volume of serum, no standardized test available, little information obtained.
Insulin	Of limited interest in healthy adult.
Cortisol	Requires large volume of plasma, little or no additional information obtained from this measurement.
Circulating ACTH	Surmounting of analytical difficulties, whether on-board or post-flight not worth the effort in terms of information obtained.
Corticosteroids	Of dubious value in blood; only transitory phenomena represented; better data derived from urine samples.
Catecholamines Urine	Requires large volume of blood; a measure of transitory phenomena only; methods much less reliable for blood than for urine where levels are more significant.
pH	Difficult measurement even in well equipped laboratory
URINE	
Tubular Reabsorption Phosphate	Renal tubule damage highly unlikely.
FECES	
Mg	Of limited interest
Trypsin	Of limited interest

ROUGH DRAFT

ROUGH DRAFT

NOT RECOMMENDED

TEST	RATIONALE
BLOOD, PLASMA OR SERUM	
TBG	No standardized test available.
TSH	Rare research technique.
Thyrocalcitonin	Large volume of blood required; bioassay semi-quantitative at best.
URINE	
Testosterone	Prohibitively large volume of urine required.
Uropepsin	Not in common clinical use; of dubious import
Manganese	Of limited special interest
Pyrophosphate	Of limited special interest
Zinc	Of limited special interest
Glucose	Of dubious significance in healthy adult
Sulfates	Of dubious significance
Renal Clearances	Requires in-flight injection of clearing agents
BLOOD, PLASMA OR SERUM	
Glucagon	No standard procedure available; change in α cells of pancreas unlikely.
Somatotrophic Hormone	Little or no significance of assay in adult.
Histamine	No highly accurate test available; test of dubious significance.
Hypothalamus	Hypothalamic activity cannot be measured directly by chemical means.
Epinephine	Large volume of serum required; other measures of stress available.
FSH	Large volume of serum required; bioassay only test available; test of dubious significance.
Norepinephrine	Large volume of serum required; other measures of stress available.

ROUGH DRAFT

ROUGH DRAFT

NOT RECOMMENDED

TEST	RATIONALE
BLOOD, PLASMA OR SERUM	
Parathyroid Hormone	Large volume of serum required; analysis extremely tedious with results that are semi-quantitative at best.
TBPA	Test not well standardized, does not add much information on thyroid function.
Triglycerides	Of limited interest
AHG	Measurement of little value in healthy adult.
ADH	More accurate measures of stress can be obtained.
Manganese	Of dubious significance
PTC	Induction of Christmas factor disease unlikely
Sulfates	Metabolic acidosis unlikely
Transferrins	Of limited interest
Leukocyte Mobilization	Change in Opsonic Index is of doubtful significance
ACTH Stimulation of 17-OH-Corticosteroids	Of dubious value in blood
Ca Infusion	On-Board infusion procedure not recommended

ROUGH DRAFT

NOT RECOMMENDED

TEST	RATIONALE
URINE	
Amylase	Changes in level occur in kidney disease and proteinuria but these conditions can be diagnosed by other simpler tests.
Uric Acid	Changes occur in leukemia, anemia and severe muscle atrophy, but these conditions can be diagnosed by other simpler tests.
Mg	Not usually measured since little excreted. Changes are open to ambiguous interpretation.
Bile	Occurs in urine only in cases of biliary obstruction. Characteristic color of urine in such a condition is a qualitative measure in itself.
Lipase	See Amylase

NOT RECOMMENDED

TEST	RATIONALE
CLINICAL CARDIOVASCULAR	
Venous Pressure (Central)	No known non-invasive method.
PROVOCATIVE TESTS AND COUNTERMEASURES	
Response to Anti-G Suit	Effect cannot conveniently be tested in orbit; include in CM if required.
GASTROINTESTINAL ACTIVITY EVALUATION	
Absorption	Double lumen intubation and radioactive tracers makes for highly complicated experiment.
Gastrointestinal Cytology	Requires intubation and lavage.

REQUIRED MEASUREMENTS

Measurement to be taken	Commentary
MUSCULOSKELETAL MEASUREMENTS:	
(3.4.4.1) Muscle Mass	Provision will be made to assess cross section or girth at selected areas of the extremities by means of constant pressure calipers, tape measures, or ultrasolics. Body mass will also be assessed as previously discussed. Measurements of skin fold thickness and lean body mass by means of calipers and a nomogram will also be accomplished to establish alterations in lean muscle mass to fat ratios.
(3.4.4.2) Muscle Strength	Both impulsive and sustained muscle strength will be assessed by either a mechanical, electronic, or pneumatic dynamometer. For the sustained measurement, the force present at the end of a four-second period will be measured. Hand dynamometry cannot be interpreted strictly in terms of strength. In a GE study involving 30 days of confinement, subjects showed a significant continued increase in mean force emission during the period. Competitiveness (i.e., who scored highest today) may have played a role. Alterations in motivation were thought to be related to fluctuations, reversals and narrowing of the differential force emission levels between dominant and non-dominant hands.
(3.4.4.3) Muscle Endurance	Endurance is a measure of the total time during which the subject is able to maintain a specific level of work output. When using the ergometer or the whole body exerciser, cardiovascular criteria may be used to establish endurance, i.e., at constant work rate, work time to criterion pulse rate.
(3.4.4.4) Neuromuscular Integrity	A series of measurements are proposed to assess the various facets of neuromuscular integrity. For quantitative data rather extensive manipulanda and displays are required.

Measurement to be taken	
(3.4.4.4.1) Voluntary Contractility	Photogrametry, as utilized in DB-39-66-055 to study voluntary motor activity and general coordination during task performance, is recommended. IMBLMS will contain a general cinematographic capability designed to accommodate anticipated requirements.
3.4.4.4.2 Reaction Time	A simple device with visual or auditory stimulus, timer, and motor response is proposed. GE underwater studies indicate a delayed simple reaction time during neutral buoyancy independent of water drag.
3.4.4.4.3 Coordination	General coordination can be assessed by performance of experiments within IMBLMS. Quantitative measures of fine coordination will require a two-dimensional tracking task which will force coordination of force emission and displacement. Gross coordination requires major body movements. The precision placement of a stylus within a three-dimensional volume can be used for quantitative data. Psychomotor behavior measures are discussed below.
(3.4.4.4.4) Kinesthetics/Proprioception	In order to assess the crewman's psychomotor function, it is necessary to study both gross (whole body) and fine (extremity) motor movement. As an aid to the study of fine motor movements, it is necessary to analyze motion in three dimensions. The least sophisticated system consists of two movie cameras which orthogonally view the test field (Figure 3-8). Data reduction, however, is tedious, since the three coordinates of hand position must be measured and plotted frame by frame. We are aware of the Stanford Institute computer program designed to facilitate this analysis. A concept presently under consideration at GE is a system which will measure hand position in spherical coordinates. The three coordinates will be recorded as electrical analog signals ideal for both computation and recording. This activity was originally intended as a means for studying cerebral palsy patients, but it deserves some consideration as an IMBLMS equipment.

Measurement to be taken	Commentary
(3.4.4.4.4) Kinesthetics/Proprioception (Cont'd)	The equipment consists of a modified "joy-stick" with an expandable handle (Figure 3-9). The joy-stick will control two pots which give an output signal proportional to the two angular coordinates of stick position. The telescoping handle contains a wire attached to a take-up spool which applies enough tension to keep the wire taut. This spool is connected through a gear train to a precision pot (Figure 3-10). The pot's reading is directly proportional to the length of the handle. With the two angular components from the joy-stick and the radial component from the handle, any position in the box of Figure 3-9 may be precisely described in spherical coordinates. There also exists the possibility of servo-driving this equipment. With the crewman grasping the handle, his hand may be led through a three-dimensional path. This could be an aid in studying proprioception.
(3.4.4.4.5) Tonus	Muscle tone will be assessed by the EMG. We would recommend an approach involving integration of the EMG signal rather than recording of the analog signal.
(3.4.4.4.6) Reflexes	Standard equipment such as a reflex hammer, tuning fork, two-point discrimination device, etc., will be included.
(3.4.4.4.7) Range of Motion	Range of motion studies can be performed quite simply with a goniometer. The device is lightweight and follows and records the range of voluntary movement at the selected joint.
(3.4.4.5) Bone Integrity	The inflight assessment of bone density by means of a gamma gauge or x-ray device, we believe, should be classified as an experimental procedure, and the equipment be provided by a separate procurement. Provision for the assessment of calcium balance is presented below.

Measurement to be taken	Commentary
(3.4.4.6) Musculoskeletal Measurements Summary	The proposed musculoskeletal measurements by and large overlap those found in the section on behavior and the gross evaluation of muscular status primarily revealed by the performance of complex tasks within the IMBLMS itself. Assessment of the biochemical status of both bone and muscle is discussed below.
(3.4.6) BEHAVIOR	
(3.4.6.1) Task-Related Performance	The most potent method for the study of performance is measurement and observation during mission-related tasks. In this situation motivation is reasonable controlled and maintained. Because of the repetitive nature of the medical experiment program and given a fixed constraint configuration, performance data as a function of time can be obtained within IMBLMS or in respect to real mission tasks. Such real complex task performance measures have many apparent advantages over relatively artificial test batteries.
(3.4.6.2) Re-entry Simulation	As mission duration is progressively extended, a requirement will ultimately arise for the maintenance of crew proficiency in the re-entry piloting task. Whether such a procedure should be a simulation (computer-driven) of the actual re-entry task (and perhaps performed in the Command Module), or should be a more sophisticated and sensitivity tracking task cannot be determined at present. Two complex tracking programs have been reviewed. We believe that such a requirement is a mission-related skills maintenance technique rather than a measure and not therefore a part of IMBLMS. This is not to say that eye/hand tracking tasks cannot be utilized for evaluating general visual/motor and coordinative functions as well as arousal and motivation levels, but rather that the data can be derived at the levels necessary with considerably simpler

Measurement to be taken	Commentary
(3.4.6.2) Re-entry Simulation (Cont'd)	instrumentation. As a matter of fact, should software capabilities be available for the instrumentation of a simulated re-entry program utilizing the actual "on-board" flight controls and displays, quantitative measures of this task during the practice sessions would be of great value as an ancillary IMBLMS measure. The presence of such capabilities are not known at the present time and therefore, the capability cannot be considered as a formal IMBLMS function.
(3.4.6.3) Neurophysiological Correlates of Behavior; The Electroencephalogram	Provision will be made in IMBLMS for the EEG. The present IMBLMS capability is 9 electrode pairs. We plan a junction box at the sleep station and another in a work area following Adey's experiments relating performance and sleep to the EEG. In the sleep station provision could also be made for the EOG if eye movement measurements are desired. We have not configured a task performance station of the complexity suggested by Adey involving visual and auditory stimuli of considerable diversity. Nor have we considered the problem of quick don-doff electrodes using a helmet device such as that under development. We have considered but not resolved the problem of EEG data management, particularly with respect to spectral analysis techniques using the on-board computer capability. In summary IMBLMS will provide the electronic capability for the EEG and junction boxes at two locations pending further definition.
(3.4.6.4.1.1) Visual Acuity	In spite of the absence of any modification in visual acuity during any of the American or Russian flights to date, it seems reasonable to include measures of acuity as part of any evaluation of overall visual function. It is also recommended that acuity measures be evolved in at least two parameters, namely: minimal detectable stimulus and two-point separation thresholds. While other measures could be added with little or no additional mass, there will be minimal gains in information. The measures recommended are dependent on the physical and metabolic integrity of the eye and its associated sensory pathways. Equipment for the quantitative assessment is readily available in the form of a flight-modified orthorater concept.

Measurements to be taken	Commentary
(3.4.6.4.1.2) Depth Perception	Measures of depth perception can provide us with information concerning not only the physical integrity of the eye and its associated neural pathways, but data regarding neuro-muscular integrity of the extraocular musculature as well as insights into the perceptual status of the cortex. The flight-modified orthorater equipment seems adequate for this measurement.
(3.4.6.4.1.3) Phorias	Visual phorias (both near and far) might be categorized as depth perception measurements. Their inclusion as a separate measure is a function of the fact that the perceptual content, mainly image fusion processes, is a different perceptual data bit in spite of the fact that essentially identical systems are involved. Simple modifications in orthorater-type instrumentation may be utilized to develop this measure.
(3.4.6.4.1.4) Dark Adaptation	The measurement of the intensity/time course of the brightness threshold of the eye provides information regarding the functional effectiveness of the iris and the general physical and metabolic health of the retina. Modifications in either portion of the system could be reflected in the time course of the dark adaptation response. The Hecht-Schlaer adaptometer may be utilized for data collection. This capability may be incorporated into an orthorater device by simply providing a precise variable light source which can be calibrated and recorded.
(3.4.6.4.1.5) Absolute Brightness Thresholds	The measurement of absolute brightness threshold across the retinal fields provide a good index of retinal function. While dark adaptation measures provide information on the dynamics of brightness sensitivity alterations, brightness sensitivity measures across the retina provide the capability to map the static functional status of the retinal field. The same equipment utilized for dark adaptation measures can be utilized for this measurement.

Measurements to be taken	Commentary
(3.4.6.4.1.6) Color Perception	While the mechanism for color perception is unknown, man's capability to utilize color information is assumed in the preparation of his instrumentation and work tasks. As a result, information regarding the integrity, sensitivity and fidelity of this capability should be considered in any complete visual assessment. The standard orthorater with appropriate stimulus material can accomplish this measure.
(3.4.6.4.1.7) Movement Detection Threshold	Man's capability to detect and/or track moving stimuli are of critical import during several phases of space flight. While man's capability to detect movement is a direct function of not only the speed of movement but the physical characteristics, size and brightness, of the stimulus, instrumentation in this area requires precision calibration and measurement. While several techniques are currently existing for this measurement, it is recommended that a unique display be evolved wherein those stimulus characteristics deemed most pertinent to space flight considerations may be incorporated. This device may be either mechanical or electronic in nature. Moderate sophistication shall be provided for the programming and measurement of movement of the stimuli. It is considered that this device is essentially state-of-the-art in that no novel or complex engineering design is required.
(3.4.6.4.1.9) Eye Movement	The final major parameter of visual function is the evaluation of the eye's capability to track dynamically. Measures in this area may be concerned either with the eye's ability to follow relatively rapidly moving stimuli across a two-dimensional area, or with the eye's capability to move across static material in a prescribed fashion.

Measurements to be taken	Commentary
(3.4.6.5.1) Measurement of Absolute Intensity Thresholds	The measurement of this parameter provides insight regarding the physical status of the tympanum, ossicles and cochlear mechanisms as well as information regarding the functional capability of the neural mechanisms as well as the perceptual status of the auditory cortex. It is assumed that information may be obtained by the use of equipment permitting the generation of precise frequency and intensity outputs to the individual ear. Two approaches have been evaluated for the IMBLMS Program: one, utilizing high fidelity magnetic tape recordings carried as on-board stimulus material; and a second technique utilizing a computer software program and associated signal generator to generate stimulus material on board.
(3.4.6.5.2) Pitch Discrimination	Essentially the same mechanisms and instrumentation can be involved in pitch discrimination measures. The inclusion of this second parameter is based on its greater utilization of perceptual mechanisms, and as such justifies inclusion.
(3.4.6.5.3) Sound Localization	This phenomenon permits the evaluation of not only the physical and perceptual functions of the auditory system, but permits the evaluation of the cortex's capability to sense and interpret time of arrival and intensity variations between two ears. In this measurement, essentially the same approach may be utilized with the exception that binaural stereophonic information be supplied in the stimulus and transmitted binaurally to the subject via stereophonic earphones.
(3.4.6.6) Kinesthetic Function	At least two major areas of kinesthetic function must be considered. In the first area questions regarding the man's capability to voluntarily or unconsciously locate himself and his extremities properly in three-dimensions, either in respect to dynamic procedures, or to attain a static orientation. In the second consideration, kinesthetics in a broad sense could include considerations of somatic or cutaneous sensations of touch. It is recommended that the following measures be considered.

Measurements to be taken	Commentary
(3.4.6.6.1) Proprioception	The subject shall be instructed to locate an extremity at a specific location in space and maintain that condition for a minimal period of time. Data in this regard may be collected via photogrametric cameras as in M055. Under the second or dynamic circumstance, the subject would be requested to carry out a gross full-body movement. Once again, data in the form of photogrametry may be collected. It is also suggested that a fine dynamic evaluation requiring precision displacement and rate of movement be measured as previously discussed.
(3.4.6.6.2) Cutaneous Touch Measurements	While kinesthetic and proprioceptive information relies on tendon and muscular stress phenomena, some information is derived from the cutaneous sensors. Measurements are therefore recommended in respect to touch thresholds, touch localizations and two-point discriminations. These measures may be accomplished by a simple standard mechanical device capable of being calibrated for precision pressure and area of contact.
(3.4.6.7) Vestibular Function	As the AAP mission time is extended in an incremental manner, the means for assessment of vestibular function will be a continuing requirement. Whether or not adaptation occurs in the vestibular system due to weightlessness is not known and NASA must continue to seek data on which ultimately to base a "G-decision", e.g., whether artificial G will be required for long-term manned space flight.
(3.4.6.8) Psychomotor Functions	Man's capability to perform precise voluntary psychomotor tasks is of critical import. Measures regarding the crewman's capability to move through three-dimensional space is considered under kinesthetic considerations. Problems relating to fine motor movement in respect to manipulation, reaction time, controlled force emission functions and comples eye/hand coordination activities should be measured. Measures in these areas may be interpreted as representing

Measurements to be taken	Commentary
(3.4.6.8) Psychomotor Functions (Cont'd)	the integrity of the overall neural, muscular, and skeletal systems involved. In spite of the relatively clear-cut measurement techniques available, no finite equipment description or package has been prepared for the accomplishment of these measures at the present time. It is hoped that as a result of further analysis, a single integrated package may be evolved for the accomplishment of all the preceding psychomotor characteristics. There is reason to believe that the three-dimensional manipulanda device, discussed under kinesthetic parameters, may be redesigned to permit the preceding measures.
(3.4.6.9) Cognitive Function	In the introduction for the section, the problem related to the delineation of measures in respect to real time quantification of cognitive function was discussed. At the present time there is reason to believe that measures of arithmetic computational capability, arousal/vigilance levels, problem solving and memory span measures would provide a basic repertoire of data collection procedures adequate for establishing cognitive status. Since, in most instances, the instrumentation for evolving these values have been custom designed for the system in which they were used, no formal equipment package is obtainable. It is our recommendation that further studies be initiated to establish optimal approaches and instrumentation for the collection of such information in order that designs specifically appropriate for the Imblms modular packaging concept be evolved.
(3.4.6.10) Emotional Adjustment	The pertinence of measurements of emotional adjustment is self-evident. Unfortunately, instrumentation to gather this information in real time is nonexistent. While combinations of measures such as polygraphic techniques have been utilized to measure changes in emotional levels, no formal equipment has been devised to quantify such changes. It is true that anxiety levels can be correlated to some extent with GSR activities and that similar reflections of

Measurements to be taken	Commentary
(3.4.6.10) Emotional Adjustment (Cont'd)	anxiety will become apparent in several of the currently contemplated bio-assay procedures. Historically, emotional measurements have been primarily accomplished by either continuous visual/acoustic monitoring of the individual and his interaction to the environment, or by direct interface by an accomplished psychiatrist familiar with the individual. While these procedures could be utilized for IMBLMS, it is suggested that such a decision not be finalized at this phase of the program.
Measurements not recommended for inclusion	
(3.4.6.4.1.8) Reading	While reading procedures are frequently utilized as measurements of general ocular motility, there is ample evidence to demonstrate that modifications in reading capability are frequently due to parameters other than visual function. Since this confounding inference cannot be separated from the data, it is recommended that reading measurements be excluded from consideration as an IMBLMS measurement technique.
(3.4.6.5.4) Speech	While the detection and discrimination of speech material is frequently included as a measure of auditory function, just as in the case of reading, many secondary considerations unrelated to auditory function play critical roles in this measure. As a result, speech perception capabilities are not recommended as an IMBLMS measure.

MEDICAL/BEHAVIORAL MEASUREMENT CAPABILITY
of

INTEGRATED MEDICAL AND BEHAVIORAL LABORATORY
MEASUREMENT SYSTEM

INCLUDE

I. NEUROLOGICAL

Clinical Evaluation (to include reflexes and sensory and motor pathways)

Agravic Perception of Personal and Extra-Personal Space (Minimum restraint device)

Ocular Counter-Rolling
Oculogyral Illusion
Visual Task with Head Rotation
Electronystagmogram
Angular Acceleration Threshold
} To be done with litter-chair

EEG

II. CARDIOVASCULAR

Clinical Evaluation

ECG (Frank Lead System)

Phonocardiogram

Cardiac Output - (By impedance if technique varified; by indicator-dilution if necessary)

Arterial Blood Pressure

Venous Pressure - Peripheral

Blood Volume and Fluid Compartments - See Hematology and Metabolism

Regional Blood Flow - Limb (or Digit) (Distribution of Blood Volume)

Venous Compliance
Arteriolar Reactivity
} (Limb Plethysmography)

INCLUDE

Arterial Pulse Contour

In-Flight Exercise

LBNP

Elastic Leotards

PROVIDE FOR INSTALLATION IF REQUIRED:

Ballistocardiogram

Carotid Body Stimulation

Thoracic Blood Flow

Venous Pressure - Central
(By Catheter if Necessary)

III. RESPIRATORY

Clinical Evaluation

Respiratory Rate

Lung Volumes Including Residual Volume
(For total lung capacity, and mixing efficiency)

Pressure, Flow, and Volume (Simultaneously)
(→ Airway Resistance)

Compliance - Lung or Total
(lung if can)

INCLUDE

Distribution of Blood Flow and Gas in Lungs

Includes: Capillary Blood O_2, CO_2, and pH

Breath by Breath O_2 Consumption and CO_2 Production

O_2 Consumption - With Measured Exercise

Alveolar to Arterial Gradient Breathing Air and 100% Oxygen

Diffusion Capacity (if suitable technique) (Look into O_2^{18} method - Dr. Richard W. Hyde, U. of Pennsylvania, Dept. of Physiology)

IV. METABOLISM AND NUTRITION

Clinical Evaluation

Energy Metabolism (Continuous O_2 and CO_2 Analysis with Breath by Breath Sensitivity) with Various Levels of Activity

Oral Temperature

Skin Temperature

Caloric Intake

Body Mass In-Flight (Thornton Technique - GFE)

[Lean Body Mass Pre- and Post-Flight] - (Not a Part of IMBLMS)

Muscle Size and Strength

Balance Studies
- Fluid, including Sweat
- Nitrogen (See Area IX)
- Mineral (See Area IX)
- Electrolyte (See Area IX)

INCLUDE

Provide for :
- Accurate Urine Volume Measurement
- Accurate Wet Weight of Feces
- Return of Total Dry Stool
- Accurate Fluid Intake Measurement
- Return of all Food Packages Marked by Date Time and Individual
- Sweat Measurement and Sample Return

Total Body Water (Breatholator or Deuterium)

† Clinical Laboratory Evaluations - See List Under Area IX

PROVIDE FOR INSTALLATION IF REQUIRED:

EMG

Bone Densitometry - Isotope Technique

Gastric Pressure and pH (Endoradiosonde)

Plasma Volume On-Board

Mineral Metabolism by Isotopic Techniques

V. ENDOCRINOLOGY

Clinical Evaluation

† Clinical Laboratory Evaluations - See List

INCLUDE

VI. HEMATOLOGY

Clinical Evaluation

Rumple Leede

Blood Volume and Fluid Compartment
Plasma Volume - RIHSA
RBC Mass - DFP^{32} or Cr^{51}
Total Body Water

RBC Survival - DFP^{32}

Clinical Laboratory Evaluations - See List

VII. MICROBIOLOGY AND IMMUNOLOGY

Clinical Evaluation

Body Microflora (Bacterial, Viral, and Fungal)

Environmental Culturing (Bacterial, Viral, and Fungal)

Clinical Laboratory Evaluations - See List

VIII. BEHAVIORAL EFFECTS

Clinical Evaluation

Sensory Test Battery (See Also Neurology)

Perceptual Evaluation (If validity of Tests Established)

Higher Thought Processes

Memory - Short and Long Term

Vigilance (By measurement of operational tasks)

INCLUDE

Learned Activity (Tracking and Reaction Time)

Recording of Crew Intercommunication with Automatic Erase in 15 Minutes if not Sampled

Time and Motion Study

IX. CLINICAL LABORATORY EVALUATIONS	Reference Area
Creatine and Creatinine - Urinary	IV
Urinary and Fecal: N, Ca, P, Na, K, Cl, and Mg	IV
Mucoproteins - Urinary (Pi)**	IV
Pyrophosphates - Urinary (Pi)**	IV
Hydroxyprolines - Urinary (probably Pi)**	IV
Total Amino Acids - Urinary (Pi)**	IV
Urinary: Osmolality, Color, Sp Gr, pH, Glucose, Protein, Bile, Blood, and Microscopic (ie., Routine Urinalysis - Inflight)	IV
Plasma Volume (probably P&P)*	IV & VI
Electrolytes - Serum	IV
Total Protein - Plasma	IV
Protein Electrophoresis - Plasma	IV
Glucose - Blood (Inflight)	IV
Ca and PO_4 - Serum (probably Pi)	IV
Bilirubin - Serum	

*P&P - pre & post-flight
**Pi - Post-flight evaluation of inflight samples

INCLUDE	Reference Area
Cholesterol - Serum (probably P1)	IV
BUN (probably P1)	IV
Uric Acid - Blood (P1)	IV
Alkaline Phosphatase - Serum (probably P1)	IV
pH, pO_2, and pCO_2 - Blood	III & IV
Bicarbonate - Blood	III & IV
CPK (Creatine Phosphokinase - Serum (P1)	IV
LDH and LDH Isoenzymes - Serum (On-board if have electrophoresis)	IV
SGOT - Serum	IV
SGPT - Serum	IV
Aldosterone - Urine (P1)	IV & V
ADH - Urinary and Serum (P1)	V
ACTH - Blood (P1)	V
Serum Free Thyroxin (T_4 - Serum) (If in-flight, will require thin layer chromatography)	V
TBPA (Probably P1)	V
17-hydroxycorticosteroids - Urine and blood (P1)	V
17-ketosteroids - Urine (P1)	V
VMA - Urine (Probably P1)	V
Metanephrines - Urine (P1)	II & V
Catechols - Urine (P1)	II & V
Histamine - Blood and Urine (P1)	II & V

INCLUDE:	Reference Area
5 Hydroxy indolacetic acid - Urinary (Probably Pi)	V
Blood Cell Morphology (RBC, WBC, and Diff - Smear will suffice for platelets)	VI
Reticulocyte Count	VI
Hematocrit	VI
Hemoglobin	VI
RBC Fragility (Osmotic)	VI
RBC Mass and Survival	VI
Bleeding Time	VI
Clotting Time	VI
Prothrombin Consumption	VI
Clot Retraction	VI
Lymphocyte Karotyping (probably Pi)	VI
WBC Mobilization (Rebuck Technique)	VI
Immunoglobulins and Fibrinogen Transferins Hemoglobin Methemoglobin	VI & VII onboard if have electrophoresis
RBC Enzyme Studies (Pi) (ref. Governing Protocol M110)	VI
Complement Titration	VII
Antibody Titration	VII

PROVIDE FOR INCLUSION IF REQUIRED:

Sulfate - Urinary	IV
TSH (Pi)	V
Growth Hormone (Pi)	V
Thyroid Bound Globulin (T_3) (Pi)	V

INCLUDE	REFERENCE AREA
PROVIDE FOR INCLUSION IF REQUIRED (Cont'd):	
Parathyroid Hormone (Radio-immune Technique - Serum) (P1)	V
Parathyroid Hormone - Urinary (Nelson Technique -(P1)	V
Calcitonin - Serum (P1)	V
Insulin Assay (P1)	V
Glucagon Assay (P1)	V
Serotonin (5 HIAA) - Blood (P1)	V
Platelet Adhesiveness	VI
Fibrinolytic Activity	VI
Blood Rheology	VI
Blood Lipids	VI