CLOSED ECOLOGICAL LIFE SUPPORT SYSTEMS (CELSS) TEST FACILITY

Presented by Dr. John Tremor

Prepared by Dr. Robert D. MacElroy
Project Manager
NASA Ames Research Center

ABSTRACT

The CELSS Test Facility (CTF) is being developed for installation on Space Station Freedom (SSF) in August 1999. It is designed to conduct experiments that will determine the effects of microgravity on the productivity of higher (crop) plants. The CTF will occupy two standard SSF racks and will accommodate approximately one square meter of growing area and a canopy height of 80 cms. The growth volume will be isolated from the external environment, allowing stringent control of environmental conditions. Temperature, humidity, oxygen, carbon dioxide, and light levels will all be closely controlled to prescribed setpoints and monitored. This level of environmental control is needed to prevent stress and allow accurate assessment of microgravity effect (10^{-3} to 10^{-6} x g). Photosynthetic rates and respiration rates, calculated through continuous recording of gas concentrations, transpiration and total and edible biomass produced will be measured. Toxic byproducts will be monitored and scrubbed. Transpiration water will be collected within the chamber and recycled into the nutrient solution. A wide variety of crop plants, e.g., wheat, soy beans, lettuce, potatoes, can be accommodated and various nutrient delivery systems and light delivery systems will be available. In the course of its development, the CTF will exploit fully, and contribute importantly, to the state-of-art in closed system technology and plant physiology - Controlled Environmental Agriculture, sensors and instrumentation, plant growth environment modeling, atmosphere control and gas concentration maintenance among a few.

SPACE STATION FREEDOM UTILIZATION CONFERENCE

AUGUST 1-6, 1992

HUNTSVILLE, AL

CELSS TEST FACILITY

PRESENTED BY DR. JOHN TREMOR

PREPARED BY DR. ROBERT D. MAC ELROY
PROJECT MANAGER
NASA AMES RESEARCH CENTER

Controlled Ecological
Life Support Systems

NASA
National Aeronautics and
Space Administration

August 5, 1992

AUGUSTINE REPORT: *OF ALL THE CRITICAL ELEMENTS FOR LONG DURATION SPACE FLIGHT, CLOSED ECOLOGICAL SYSTEMS REMAIN AMONG THE LEAST UNDERSTOOD AND THE MOST CHALLENGING*

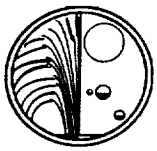
- BIOREGENERATIVE LIFE SUPPORT SYSTEMS WILL OPERATE WITH A COMBINATION OF BIOLOGICAL (e.g., HIGHER PLANTS (WHEAT,)), PHYSICAL AND CHEMICAL COMPONENTS, TO RECYCLE THE WATER, OXYGEN, FOOD AND CARBON DIOXIDE NEEDED BY HUMAN CREWS
- THE NASA CELSS PROGRAM IS CHARGED WITH DEVELOPMENT OF THE SCIENCE AND TECHNOLOGIES NECESSARY TO CONSTRUCT BIOREGENERATIVE LIFE SUPPORT SYSTEMS FOR USE IN SPACE
- THE CELSS TEST FACILITY IS BEING DESIGNED TO GROW HIGHER PLANT CROPS ON SPACE STATION FREEDOM UNDER STRINGENTLY CONTROLLED ENVIRONMENTAL CONDITIONS FOR THE PURPOSE OF DETERMINING CROP PRODUCTIVITY

Controlled Ecological Life Support Systems

NASA
National Aeronautics and Space Administration

August 5, 1992

- THE CELSS PROGRAM HAS SUPPORTED MAJOR RESEARCH EFFORTS THAT HAVE FOCUSED ON HIGHER PLANT PRODUCTIVITY
    - PRODUCTIVITY IS DEFINED AS THE RATE OF PRODUCTION OF FOOD, WATER OR OXYGEN PER UNIT OF RESOURCE USE (E.G., AREA, VOLUME, KW POWER, ETC.)
- CELSS RESEARCH HAS EXPLORED THE UPPER LIMITS OF HIGHER PLANT PRODUCTIVITY AT 1 x *g* BY INVESTIGATING THE EFFECTS OF ENVIRONMENTAL CONDITIONS ON PLANT GROWTH RATES
    - FOR EXAMPLE, WHEAT CROPS GROWN UNDER RIGOROUSLY CONTROLLED ENVIRONMENTAL CONDITIONS EXCEED FIELD PRODUCTIVITY FIVE-FOLD



Controlled Ecological Life Support Systems

NASA
National Aeronautics and Space Administration

August 5, 1992

- A MAJOR UNKNOWN IS THE PRODUCTIVITY OF PLANTS IN SPACE: IN ORBIT AT MICRO-GRAVITY (10^{-6} TO 10^{-3} x *g*), ON THE MOON'S SURFACE (0.16 x *g*) AND ON MAR'S SURFACE (0.38 x *g*)
- WHILE THE INITIAL USE OF THE CELSS TEST FACILITY WILL BE ON SPACE STATION FREEDOM, THE FACILITY CAN BE ADAPTED TO STUDY PLANT GROWTH ON THE MOON'S SURFACE AS A LABORATORY INSTRUMENT IN AN EARLY LUNAR BASE

Science and Technology Working Group

Robert	MacElroy	NASA/AMES Research Center
John	Tremor	Bionetics/AMES Research Center
Marcel	Andre	Cadarache Research Center (CEA) France
Charles	Blackwell	University of Texas/AMES Research Center
Ray	Bula	U Wisconsin/WCSAR
Joe	Cowles	Virginia Technical University
Joe	Gale	Hebrew University of Jerusalem
Arthur	Galston	Yale University
Gary	Jahns	NASA/AMES Research Center
William	Knott	NASA/Kennedy Space Center
Marv	Luttges	University of Colorado/Aerospace Engineering Science
Ralph	Mitchell	Harvard University/Division of Applied Science
Cary	Mitchell	Purdue University/Department of Horticulture
Frank	Salisbury	Utah State University/Plants Soils and Biometeorology Department
Tyler	Volk	New York University
Richard	Wisniewski	NASA/AMES Research Center

Controlled Ecological
Life Support Systems

NASA
National Aeronautics and
Space Administration

August 5, 1992

Controllable Environmental Conditions

Chamber Parameters:

Temperature	18-40 deg C	± 1 deg C
Humidity	60-80% RH	± 10%
O_2 Level	5-23.7 kPa	± 5%
CO_2 Level	300-5000 μmols/mol	± 10 μmols/mol
Lights	on/off	
Light Intensity	200-2000 $\mu mols/m^2/s$	± 5%

Crop:

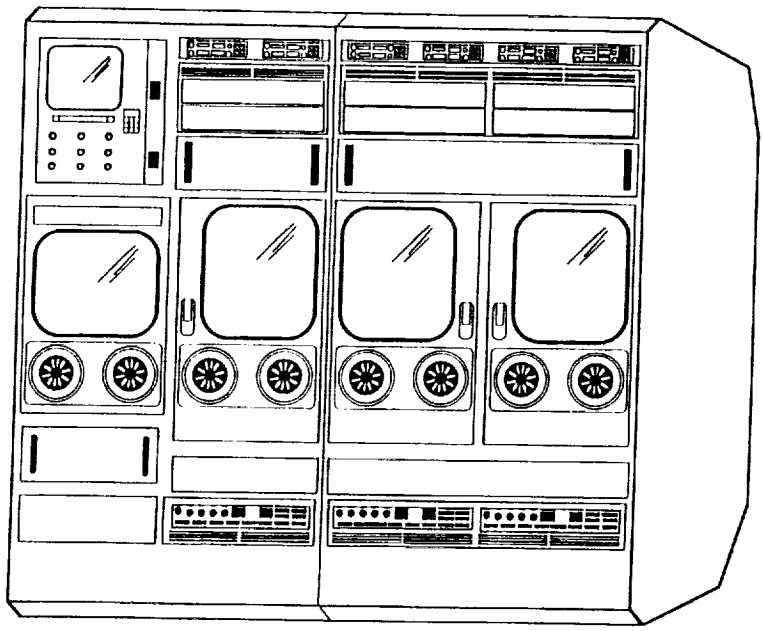
- Cultivars
- Species
- Genetic Engineering
- Polyculture

Controlled Ecological Life Support Systems

NASA
National Aeronautics and Space Administration

August 5, 1992

Early Concept



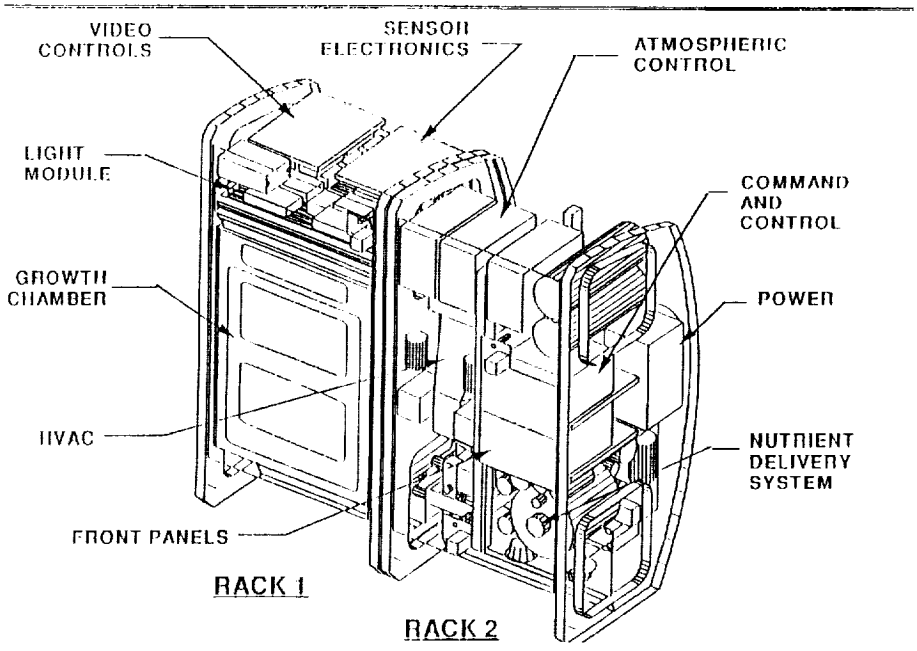
CELSS TEST FACILITY PROJECT

Controlled Ecological Life Support Systems

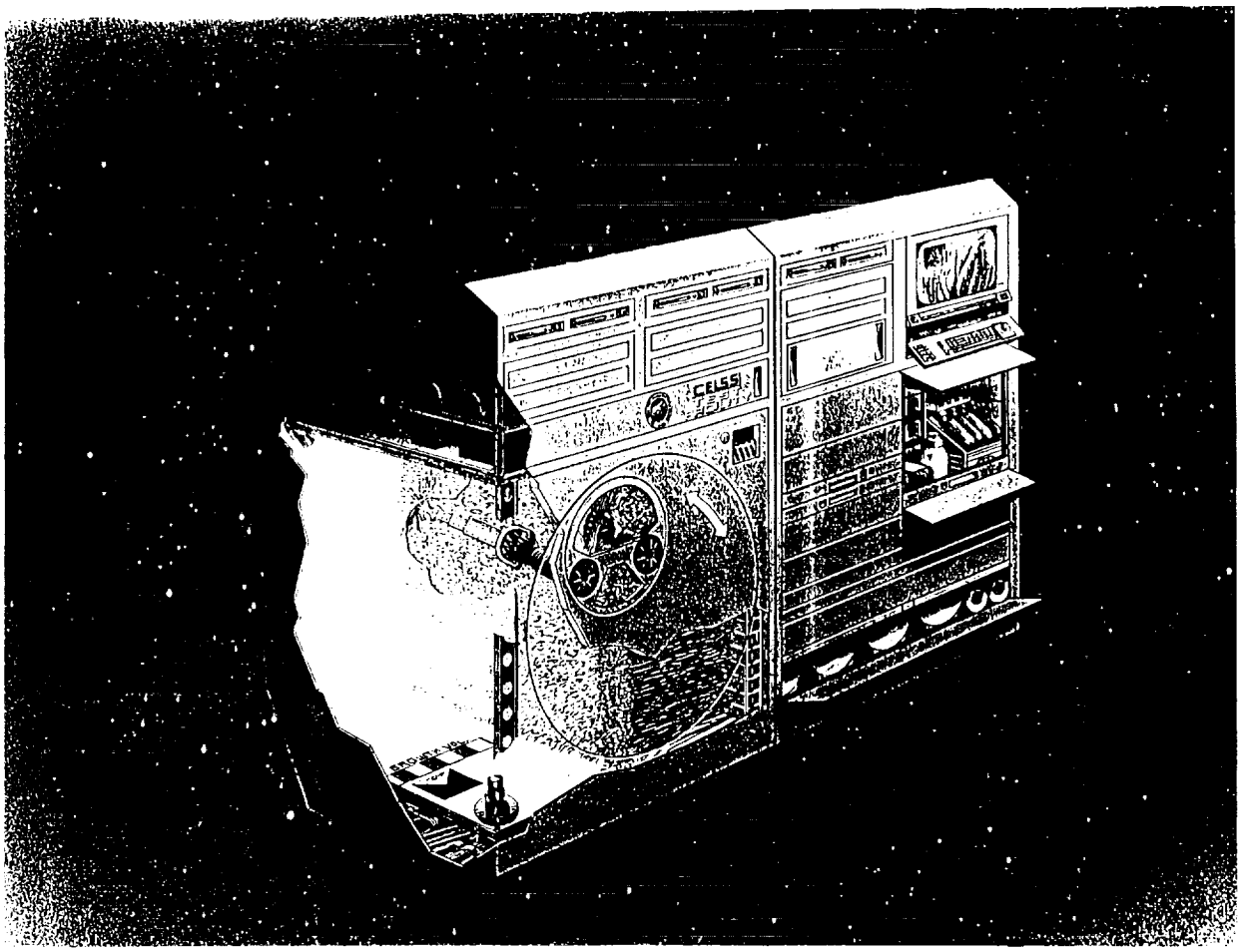
NASA
National Aeronautics and Space Administration

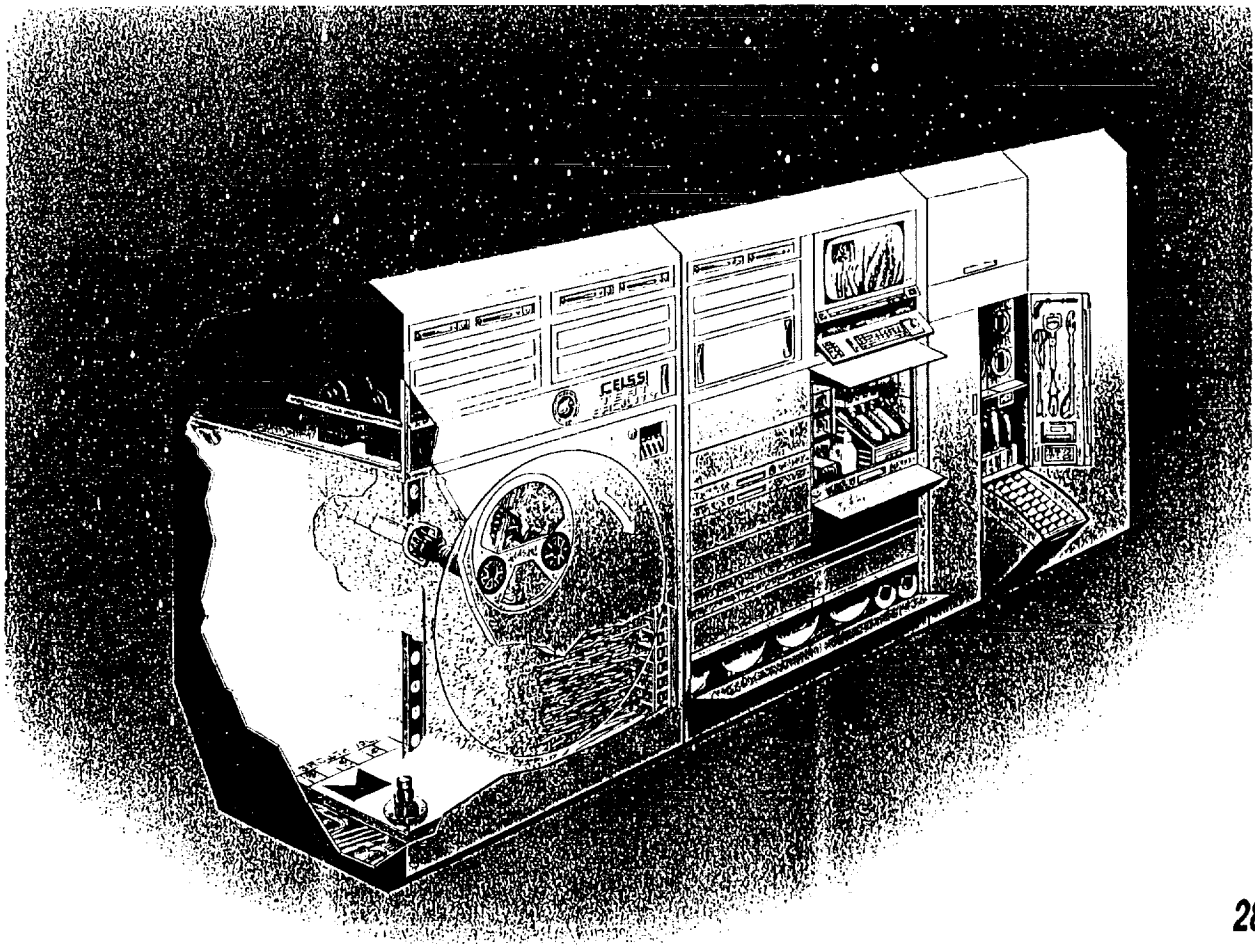
August 5, 1992

Rack Assembly

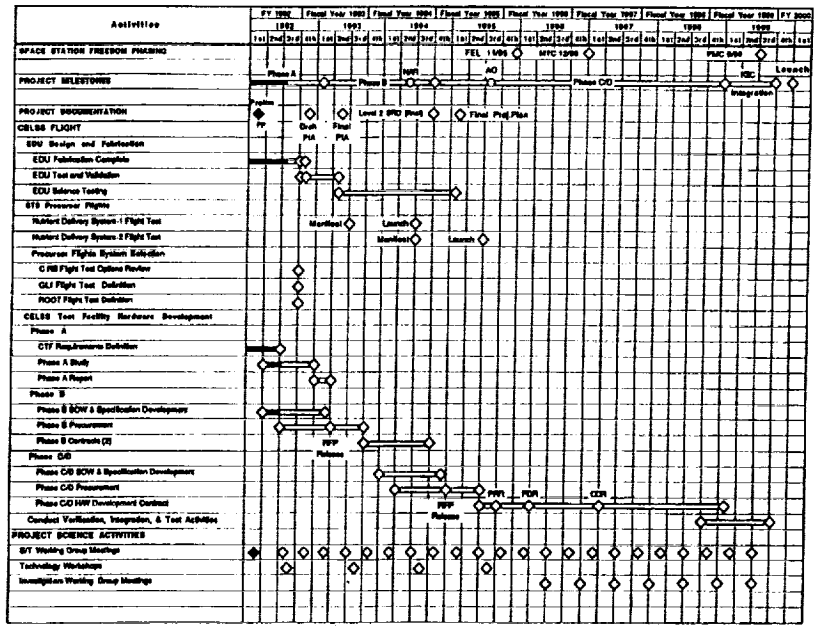


CELSS TEST FACILITY PROJECT





CELSS TEST FACILITY PROJECT SCHEDULE



CELSS TEST FACILITY PROJECT