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Closed-Loop Life Support and Habitability: 2000-2004

A Custom Bibliography From the
NASA Scientific and Technical Information Program

October 2004

Closed-Loop Life Support and Habitability: 2000-2004

This custom bibliography from the NASA Scientific and Technical Information Program lists a sampling of records found in the NASA Aeronautics and Space Database. The scope of this topic includes technologies for the recycling of oxygen, carbon dioxide, and water for long-duration human presence in space. This area of focus is one of the enabling technologies as defined by NASA's *Report of the President's Commission on Implementation of United States Space Exploration Policy*, published in June 2004.

OCTOBER 2004

20040094860

How we will go to Mars

Kiforenko, B. N., Author; Vasil'ev, I. Yu, Author; Acta astronautica; Jan 2004; ISSN 0094-5765; Volume 54, Issue 1, 61-7; In English; Copyright; Avail: Other Sources

This article studies the efficiency of ejecting waste generated by the life support system (LSS) of a manned spacecraft to reduce initial mass on low earth orbit. The spacecraft is used for a long-duration interplanetary mission and is equipped with either a chemical or a nuclear-thermal propulsion system. For this study we simulate an optimal control problem for a given spacecraft maneuver. An impulsive approximation of the optimal interplanetary spacecraft trajectory is assumed, which allows us to reduce the general optimal control problem to hierarchic structure of 'outer' and 'inner' subproblems. This structure is analyzed using the Pontryagin's Maximum principle. Numerical results, illustrating the efficiency of waste ejection are shown for typical Earth-Mars transfer trajectories. This results confirm in theory that using a waste ejection system makes an early manned Mars mission possible without having to design and build new, advanced biological LSS. c2003 Elsevier Ltd. All rights reserved.

NLM

Closed Ecological Systems; Life Support Systems; Mars (Planet); Models; Waste Management

20040121161 NASA Marshall Space Flight Center, Huntsville, AL, USA

Microlith Based Sorber for Removal of Environmental Contaminants

Roychoudhury, S.; Perry, J.; [2004]; In English

Contract(s)/Grant(s): NAS8-02108

Report No.(s): SAE-2004-01-2442; Copyright; Avail: Other Sources

The development of energy efficient, lightweight sorption systems for removal of environmental contaminants in space flight applications is an area of continuing interest to NASA. The current CO2 removal system on the International Space Station employs two pellet bed canisters of 5A molecular sieve that alternate between regeneration and sorption. A separate disposable charcoal bed removes trace contaminants. An alternative technology has been demonstrated using a sorption bed consisting of metal meshes coated with a sorbent, trademarked and patented as Microlith by Precision Combustion, Inc. (PCI); thesemeshes have the potential for direct electrical heating for this application. This allows the bed to be regenerable via resistive heating and offers the potential for shorter regeneration times, reduced power requirement, and net energy savings vs. conventional systems. The capability of removing both CO2 and trace contaminants within the same bed has also been demonstrated. Thus, the need for a separate trace contaminant unit is eliminated resulting in an opportunity for significant weight savings. Unlike the charcoal bed, zeolites for trace contaminant removal are amenable to periodic regeneration. This paper describes the design and performance of a prototype sorber device for simultaneous CO2 and trace contarninant removal and its attendant weight and energy savings.

Author

Trace Contaminants; Reactor Technology; Sorbents; Catalysts; Environment Pollution

20040045253 Science Applications International Corp., USA

Integrated System Design for Air Revitalization in Next Generation Crewed Spacecraft

Mulloth, Lila; Perry, Jay; LeVan, Douglas; January 2004; In English, 19-22 Jul. 2004, Colorado Springs, CO, USA; No Copyright; Avail: Other Sources; Abstract Only

The capabilities of NASA's existing environmental control and life support (ECLS) system designs are inadequate for future human space initiatives that involve long-duration space voyages and interplanetary missions. This paper discusses the concept of an integrated system of CO2 removal and trace contaminant control units that utilizes novel gas separation and

purification techniques and optimized thermal and mechanical design, for future spacecraft. The integration process will enhance the overall life and economics of the existing systems by eliminating multiple mechanical devices with moving parts.
Author
Life Support Systems; Systems Integration; Air Purification; Spacecrews; Interplanetary Spacecraft; NASA Space Programs; Mechanical Engineering

20040085932 NASA Marshall Space Flight Center, Huntsville, AL, USA
Status of the Node 3 Regenerative ECLSS Water Recovery and Oxygen Generation Systems
Carrasquillo, Robyn L.; Cloud, Dale; Bedard, Jake; [2004]; In English, 19-22 Jul. 2004, Colorado Springs, CO, USA; No Copyright; Avail: Other Sources; Abstract Only

NASA's Marshall Space Flight Center is providing three racks containing regenerative water recovery and oxygen generation systems (WRS and OGS) for flight on the International Space Station's (ISS) Node 3 element. The major assemblies included in these racks are the Water Processor Assembly (WPA), Urine Processor Assembly (UPA), Oxygen Generation Assembly (OGA), and the Power Supply Module (PSM) supporting the OGA. The WPA and OGA are provided by Hamilton Sundstrand Space Systems International (HSSSI), while the UPA and PSM are being designed and manufactured in-house by MSFC. The assemblies are completing the manufacturing phase and are in various stages of ORU and system level testing, to be followed by integration into the flight racks. This paper gives a current status, along with technical challenges encountered and lessons learned.
Author
Life Support Systems; Oxygen Production; Water Reclamation; Aerospace Systems; International Space Station

20040085897 NASA Marshall Space Flight Center, Huntsville, AL, USA
Evolution of the Baseline ISS ECLSS Technologies: The Next Logical Steps
Carrasquillo, Robyn L.; Bagdigian, Bob; Perry, Jay; Lewis, John; Williams, Dave; [2004]; In English, 19-22 Jul. 2004, Colorado Springs, CO, USA; No Copyright; Avail: Other Sources; Abstract Only

The baseline Environmental Control and Life Support Systems which are currently deployed on the International Space Station or planned to be launched in Node 3 are based on technologies selected in the early 1990's. While they are generally meeting or exceeding requirements for supporting the ISS crew, lessons learned from years of on orbit and ground testing, new advances in technology state of the art, and requirements for future manned missions prompt consideration of the next logical step to enhance these systems to increase performance, robustness, reliability, and reduce on-orbit and logistical resource requirements. This paper discusses the current state of the art in ISS ECLSS technologies, and possible areas for enhancement/improvement. Potential utilization of the ISS as a testbed for on-orbit checkout of selected technology improvements is also addressed.
Author
Environmental Control; Life Support Systems; International Space Station; Ground Tests; Robustness (Mathematics)

20040084221 NASA Marshall Space Flight Center, Huntsville, AL, USA
Past, Present and Future Advanced ECLS Systems for Human Exploration of Space
Mitchell, Kenny; Strategic Research to Enable NASA's Exploration Missions Conference; June 2004, 33; In English; No Copyright; Abstract Only; Available from CASI only as part of the entire parent document

This paper will review the historical record of NASA's regenerative life support systems flight hardware with emphasis on the complexity of spiral development of technology as related to the International Space Station program. A brief summary of what constitutes ECLSS designs for human habitation will be included and will provide illustrations of the complex system/system integration issues. The new technology areas which need to be addressed in our future Code T initiatives will be highlighted. The development status of the current regenerative ECLSS for Space Station will be provided for the Oxygen Generation System and the Water Recovery System. In addition, the NASA is planning to augment the existing ISS capability with a new technology development effort by Code U/Code T for CO2 reduction (Sabatier Reactor). This latest ISS spiral development activity will be highlighted in this paper.
Author
Oxygen Production; Life Support Systems; Carbon Dioxide; Complex Systems; Regeneration (Engineering)

20040092988

Microbial utilisation of natural organic wastes

Ilyin, V. K., Author; Smirnov, I. A., Author; Soldatov, P. E., Author; Korniushenkova, I. N., Author; Grinin, A. S., Author; Lykov, I. N., Author; Safronova, S. A., Author; Acta astronautica; Mar 2004; ISSN 0094-5765; Volume 54, Issue 5, 357-61; In English; Copyright; Avail: Other Sources

The waste management strategy for the future should meet the benefits of humanity safety, respect principals of planet ecology, and compatibility with other habitability systems. For these purpose the waste management technologies, relevant to application of the biodegradation properties of bacteria are of great value. The biological treatment method is based upon the biodegradation of organic substances by various microorganisms. The advantage of the biodegradation waste management in general: it allows to diminish the volume of organic wastes, the biological hazard of the wastes is controlled, and this system may be compatible with the other systems. The objectives of our study were: to evaluate effectiveness of microbial biodegradation of non-pretreated substrate, to construct phneumoautomatic digester for organic wastes biodegradation, and to study microbial characteristics of active sludge samples used as inoculi in biodegradation experiment. The technology of vegetable wastes treatment was elaborated in IBMP and BMSTU. For this purpose the special unit was created where the degradation process is activated by enforced reinvention of portions of elaborated biogas into digester. This technology allows to save energy normally used for electromechanical agitation and to create optimal environment for anaerobic bacteria growth. The investigations were performed on waste simulator, which imitates physical and chemical content of food wastes calculated basing on the data on food wastes of moderate Russian city. The volume of created experimental sample of digester is 40 l. The basic system elements of device are digesters, gas receiver, remover of drops and valve monitoring and thermal control system. In our testing we used natural food wastes to measure basic parameters and time of biodegradation process. The diminution rate of organic gained 76% from initial mass taking part within 9 days of fermentation. The biogas production achieved 46 l per 1 kg of substrate. The microbial studies of biodegradation process revealed following peculiarities: (i) gradual quantitative increasing of Lactobacillus sp. (from 10(3) to 10(5) colony forming units (CFU) per ml), (ii) activation of Clostridia sp. (from 10(2) to 10(4)CFU/ml), (iii) elimination of aerobic conventional pathogens (Enterobacteriaceae sp., Protea sp., staphylococci). The obtained results allow to evaluate effectiveness of proposed technology and to determine the leading role of lactobacilli and clostridia in process of natural wastes biodegradation. Our further investigations shall further be concentrated on creation of artificial inoculi for launching of food wastes biodegradation. These inoculi will include active and adapted strains of clostridia and lactobacilli. c2003 Elsevier Ltd. All rights reserved.

NLM

Biomass; Bioreactors; Computerized Simulation; Microorganisms; Sewage; Utilization; Waste Management

20040096554

Plant-centered biosystems in space environments: technological concepts for developing a plant genetic assessment and control system

Lomax, Terri L., Author; Findlay, Kirk A., Author; White, T. J., Author; Winner, William E., Author; Gravitational and space biology bulletin : publication of the American Society for Gravitational and Space Biology; Jun 2003; ISSN 1089-988X; Volume 16, Issue 2, 91-9; In English; Copyright; Avail: Other Sources

Plants will play an essential role in providing life support for any long-term space exploration or habitation. We are evaluating the feasibility of an adaptable system for measuring the response of plants to any unique space condition and optimizing plant performance under those conditions. The proposed system is based on a unique combination of systems including the rapid advances in the field of plant genomics, microarray technology for measuring gene expression, bioinformatics, gene pathways and networks, physiological measurements in controlled environments, and advances in automation and robotics. The resulting flexible module for monitoring and optimizing plant responses will be able to be inserted as a cassette into a variety of platforms and missions for either experimental or life support purposes. The results from future plant functional genomics projects have great potential to be applied to those plant species most likely to be used in space environments. Eventually, it will be possible to use the plant genetic assessment and control system to optimize the performance of any plant in any space environment. In addition to allowing the effective control of environmental parameters for enhanced plant productivity and other life support functions, the proposed module will also allow the selection or engineering of plants to thrive in specific space environments. The proposed project will advance human exploration of space in the near- and mid-term future on the International Space Station and free-flying satellites and in the far-term for longer duration missions and eventual space habitation.

NLM

Closed Ecological Systems; Genes; Genetics; Life Support Systems; Plants (Botany); Weightlessness

20040087862

Life support approaches for Mars missions

Drysdale, A. E., Author; Ewert, M. K., Author; Hanford, A. J., Author; Advances in space research : the official journal of the Committee on Space Research (COSPAR); 2003; Volume 31, Issue 1, 51-61; In English

Contract(s)/Grant(s): NAS9-98119; NAS9-19100; Copyright; Avail: Other Sources

Life support approaches for Mars missions are evaluated using an equivalent system mass (ESM) approach, in which all significant costs are converted into mass units. The best approach, as defined by the lowest mission ESM, depends on several mission parameters, notably duration, environment and consequent infrastructure costs, and crew size, as well as the characteristics of the technologies which are available. Generally, for the missions under consideration, physicochemical regeneration is most cost effective. However, bioregeneration is likely to be of use for producing salad crops for any mission, for producing staple crops for medium duration missions, and for most food, air and water regeneration for long missions (durations of a decade). Potential applications of in situ resource utilization need to be considered further. c2002 Published by Elsevier Science Ltd on behalf of COSPAR.

NLM

Closed Ecological Systems; Economics; Life Support Systems; Mars (Planet); Mars Missions

20040097660

Engineering of closed ecological system in space and inter-organismal interactions

Yamashita, Masamichi, Author; Uchu seibutsu kagaku; Jun 2003; ISSN 0914-9201; Volume 17, Issue 1, 51-3; In English; Copyright; Avail: Other Sources

Space agriculture is a concept of synthesis and operation of closed ecological system for controlling living environment and supplying materials in order to sustain life and to meet metabolic needs of space crew. It revitalizes metabolites and other excretion of crew for their recycled usage. It is an advanced concept for life support for long and large scaled manned space missions, where open loop system for materials cycle is not feasible to apply. Several issues, such as cost-benefit analysis with considering benefits of amenity and psychological factors of crew, are discussed in this essay, together with reliability and productivity of biological systems. Studies on plant physiology for inter-organismal interaction contribute to design work for space agriculture, and associate with our engagements to our future, sustainable development of our civilization both on the earth and extending to outer space.

NLM

Closed Ecological Systems; Life Support Systems; Weightlessness

20040102967

The ‘C.E.B.A.S. MINI-MODULE’: a self-sustaining closed aquatic ecosystem for spaceflight experimentation

Blum, V., Author; Andriske, M., Author; Ludwig, Ch, Author; Paassen, U., Author; Voeste, D., Author; Advances in space research : the official journal of the Committee on Space Research (COSPAR); 2003; Volume 31, Issue 1, 201-10; In English; Copyright; Avail: Other Sources

The C.E.B.A.S. MINI-MODULE is the miniaturized space flight version of the Closed Equilibrated Biological Aquatic System (C.E.B.A.S.). It fits into a large middeck locker tray and is scheduled to be flown in the STS 85 and in the NEUROLAB missions. Its volume is about 9 liters and it consists of two animal tanks, a plant cultivator, and a bacteria filter in a monolithic design. An external sensor unit is connected to a data acquisition/control unit. The system integrates its own biological life support. The CO2 exhaled by the consumers (fishes, snails, microorganisms) is assimilated by water plants (Ceratophyllum demersum) which provide them with oxygen. The products of biomass degradation and excretion (mainly ammonia ions) are converted by bacteria into nitrite and nitrate. The latter is taken up by the plants as a nitrogen source together with other ions like phosphate. The plants convert light energy into chemical energy and their illumination is regulated via the oxygen concentration in the water by the control unit. In ground laboratory tests the system exhibited biological stability up to three month. The buffer capacity of the biological filter system is high enough to eliminate the degradation products of about one half of the dead animal biomass as shown in a ‘crash test’. A test series using the laboratory model of the flight hardware demonstrated the biological stability and technical reliability with mission-identical loading and test duration. A comprehensive biological research program is established for the C.E.B.A.S. MINI-MODULE in which five German and three U.S.-American universities as well as the Russian Academy of Sciences are involved. c2002 Published by Elsevier Science Ltd on behalf of COSPAR.

NLM

Aquiculture; Closed Ecological Systems; Ecosystems; Life Support Systems; Space Flight

20040096553

The space elevator: a new tool for space studies

Edwards, Bradley C., Author; Gravitational and space biology bulletin : publication of the American Society for Gravitational and Space Biology; Jun 2003; ISSN 1089-988X; Volume 16, Issue 2, 101-5; In English; Copyright; Avail: Other Sources

The objective has been to develop a viable scenario for the construction, deployment and operation of a space elevator using current or near future technology. This effort has been primarily a paper study with several experimental tests of specific systems. Computer simulations, engineering designs, literature studies and inclusion of existing programs have been utilized to produce a design for the first space elevator. The results from this effort illustrate a viable design using current and near-term technology for the construction of the first space elevator. The timeline for possible construction is within the coming decades and estimated costs are less than $10 B. The initial elevator would have a 5 ton/day capacity and operating costs near $100/lb for payloads going to any Earth orbit or traveling to the Moon, Mars, Venus or the asteroids. An operational space elevator would allow for larger and much longer-term biological space studies at selectable gravity levels. The high-capacity and low operational cost of this system would also allow for inexpensive searches for life throughout our solar system and the first tests of environmental engineering. This work is supported by a grant from the NASA Institute for Advanced Concepts (NIAC).

NLM

Aerospace Medicine; Architecture; Elevators (Lifts); Space Tools

20030032422 NASA Kennedy Space Center, Cocoa Beach, FL, USA, Dynamac Corp., Cocoa Beach, FL, USA

Crop Production for Advanced Life Support Systems - Observations From the Kennedy Space Center Breadboard Project

Wheeler, R. M.; Sager, J. C.; Prince, R. P.; Knott, W. M.; Mackowiak, C. L.; Stutte, G. W.; Yorio, N. C.; Ruffe, L. M.; Peterson, B. V.; Goins, G. D.; February 2003; In English; Original contains black and white illustrations

Report No.(s): NASA/TM-2003-211184; NAS 1.15:211184; No Copyright; Avail: CASI; A04, Hardcopy

The use of plants for bioregenerative life support for space missions was first studied by the US Air Force in the 1950s and 1960s. Extensive testing was also conducted from the 1960s through the 1980s by Russian researchers located at the Institute of Biophysics in Krasnoyarsk, Siberia, and the Institute for Biomedical Problems in Moscow. NASA initiated bioregenerative research in the 1960s (e.g., Hydrogenomonas) but this research did not include testing with plants until about 1980, with the start of the Controlled Ecological Life Support System (CELSS) Program. The NASA CELSS research was carried out at universities, private corporations, and NASA field centers, including Kennedy Space Center (KSC). The project at KSC began in 1985 and was called the CELSS Breadboard Project to indicate the capability for plugging in and testing various life support technologies; this name has since been dropped but bioregenerative testing at KSC has continued to the present under the NASA s Advanced Life Support (ALS) Program. A primary objective of the KSC testing was to conduct pre-integration tests with plants (crops) in a large, atmospherically closed test chamber called the Biomass Production Chamber (BPC). Test protocols for the BPC were based on observations and growing procedures developed by university investigators, as well as procedures developed in plant growth chamber studies at KSC. Growth chamber studies to support BPC testing focused on plant responses to different carbon dioxide (CO2) concentrations, different spectral qualities from various electric lamps, and nutrient film hydroponic culture techniques.

Author

Closed Ecological Systems; Crop Growth; Ecosystems; Life Support Systems; Protocol (Computers); Plants (Botany)

20040101085

[Selection of a SHF-plasma device for carbon dioxide and hydrogen recycling in a physical-chemical life support system]

Klimarev, S. I., Author; Aviakosmicheskaia i ekologicheskaia meditsina = Aerospace and environmental medicine; 2003; ISSN 0233-528X; Volume 37, Issue 1, 64-7; In Belorussian; Copyright; Avail: Other Sources

A waveguide SHF plasmotron was chosen for carbon dioxide and hydrogen recycling in a low-temperature plasma in the Bosch reactor. To increase electric intensity within the discharge capacitor, thickness of the waveguide thin wall was changed for 10 mm. A method for calculating the compensated exponential smooth transition to align two similar lines (waveguides) with sections of 72 x 34 mm and 72 x 10 mm to transfer SHF energies from the generator to plasma was proposed. Calculation of the smooth transition has been used in final refinement of the HSF plasmotron design as a component of a physical-chemical LSS.

NLM

Carbon Dioxide; Closed Ecological Systems; Hydrogen; Life Support Systems; Plasmas (Physics); Radio Waves; Recycling; Superhigh Frequencies

20040087847

Initial closed operation of the CELSS Test Facility Engineering Development Unit

Kliss, M., Author; Blackwell, C., Author; Zografos, A., Author; Drews, M., Author; MacElroy, R., Author; McKenna, R., Author; Heyenga, A. G., Author; Advances in space research : the official journal of the Committee on Space Research (COSPAR); 2003; Volume 31, Issue 1, 263-70; In English; Copyright; Avail: Other Sources

As part of the NASA Advanced Life Support Flight Program, a Controlled Ecological Life Support System (CELSS) Test Facility Engineering Development Unit has been constructed and is undergoing initial operational testing at NASA Ames Research Center. The Engineering Development Unit (EDU) is a tightly closed, stringently controlled, ground-based testbed which provides a broad range of environmental conditions under which a variety of CELSS higher plant crops can be grown. Although the EDU was developed primarily to provide near-term engineering data and a realistic determination of the subsystem and system requirements necessary for the fabrication of a comparable flight unit, the EDU has also provided a means to evaluate plant crop productivity and physiology under controlled conditions. This paper describes the initial closed operational testing of the EDU, with emphasis on the hardware performance capabilities. Measured performance data during a 28-day closed operation period are compared with the specified functional requirements, and an example of inferring crop growth parameters from the test data is presented. Plans for future science and technology testing are also discussed. Published by Elsevier Science Ltd on behalf of COSPAR.

NLM

Air Conditioning; Closed Ecological Systems; Life Support Systems; Product Development; Test Facilities; Vegetables

20040093630

The New Face of Space: selected proceedings of the 53rd International Astronautical Federation Congress, Houston, Texas, USA, 10 October - 19 October 2002

Acta astronautica; Aug-Nov 2003; ISSN 0094-5765; Volume 53, Issue 4-10, 237-846; In English; Copyright; Avail: Other Sources

No abstract available

Aeronautical Engineering; Conferences; Houston (TX); Technologies; Weightlessness

20040093629

Synthesis of biomass and utilization of plants wastes in a physical model of biological life-support system

Tikhomirov, A. A., Author; Ushakova, S. A., Author; Manukovsky, N. S., Author; Lisovsky, G. M., Author; Kudenko, Yu A., Author; Kovalev, V. S., Author; Gribovskaya, I. V., Author; Tirrannen, L. S., Author; Zolotukhin, I. G., Author; Gros, J. B., Author; Lasseur, Ch, Author; Acta astronautica; Aug-Nov 2003; ISSN 0094-5765; Volume 53, Issue 4-10, 249-57; In English; Copyright; Avail: Other Sources

The paper considers problems of biosynthesis of higher plants' biomass and 'biological incineration' of plant wastes in a working physical model of biological LSS. The plant wastes are 'biologically incinerated' in a special heterotrophic block involving Californian worms, mushrooms and straw. The block processes plant wastes (straw, haulms) to produce soil-like substrate (SLS) on which plants (wheat, radish) are grown. Gas exchange in such a system consists of respiratory gas exchange of SLS and photosynthesis and respiration of plants. Specifics of gas exchange dynamics of high plants--SLS complex has been considered. Relationship between such a gas exchange and PAR irradiance and age of plants has been established. Nitrogen and iron were found to the first to limit plants' growth on SLS when process conditions are deranged. The SLS microflora has been found to have different kinds of ammonifying and denitrifying bacteria which is indicative of intensive transformation of nitrogen-containing compounds. The number of physiological groups of microorganisms in SLS was, on the whole, steady. As a result, organic substances--products of exchange of plants and microorganisms were not accumulated in the medium, but mineralized and assimilated by the biocenosis. Experiments showed that the developed model of a man-made ecosystem realized complete utilization of plant wastes and involved them into the intrasystem turnover. c2003 International Astronautical Federation. Published by Elsevier Science Ltd. All rights reserved.

NLM

Biomass; Closed Ecological Systems; Environment Models; Life Support Systems; Plant Physiology; Plants (Botany); Waste Management

20040103026

New problems to be solved for establishing closed life support system

Nitta, Keiji, Author; Advances in space research : the official journal of the Committee on Space Research (COSPAR); 2003; Volume 31, Issue 1, 63-8; In English; Copyright; Avail: Other Sources

New test bed facilities such as Bioplex and CEEF have been constructed to test the new advanced technologies for solving the various problems as follows, (1) how to develop air content stabilization technologies with gas balance between the generation and the absorption by living organisms, (2) how to solve the mismatching between the assimilation rate of autotrophic organisms and the respiration rate of heterotrophic organisms, (3) how to balance the speed of the waste decomposition with the absorption speed of nutrient components in the sequential plant cultivation, (4) how to develop new nutrient adjusting subsystems for each plant species, (5) how to compensate the denitrification during the waste decomposition and anaerobic microbes in the nutrient solution. c2002 COSPAR. Published by Elsevier Science Ltd. All rights reserved.

NLM

Air Conditioning; Closed Ecological Systems; Environmental Control; Life Support Systems

20040087848

Performance of the CELSS Antarctic Analog Project (CAAP) crop production system

Bubenheim, D. L., Author; Schlick, G., Author; Wilson, D., Author; Bates, M., Author; Advances in space research : the official journal of the Committee on Space Research (COSPAR); 2003; Volume 31, Issue 1, 255-62; In English; Copyright; Avail: Other Sources

Regenerative life support systems potentially offer a level of self-sufficiency and a decrease in logistics and associated costs in support of space exploration and habitation missions. Current state-of-the-art in plant-based, regenerative life support requires resources in excess of allocation proposed for candidate mission scenarios. Feasibility thresholds have been identified for candidate exploration missions. The goal of this paper is to review recent advances in performance achieved in the CELSS Antarctic Analog Project (CAAP) in light of the likely resource constraints. A prototype CAAP crop production chamber has been constructed and operated at the Ames Research Center. The chamber includes a number of unique hardware and software components focused on attempts to increase production efficiency, increase energy efficiency, and control the flow of energy and mass through the system. Both single crop, batch production and continuous cultivation of mixed crops production studies have been completed. The crop productivity as well as engineering performance of the chamber are described. For each scenario, energy required and partitioned for lighting, cooling, pumping, fans, etc. is quantified. Crop production and the resulting lighting efficiency and energy conversion efficiencies are presented. In the mixed-crop scenario, with 27 different crops under cultivation, 17 m2 of crop area provided a mean of 515 g edible biomass per day (85% of the approximate 620 g required for one person). Enhanced engineering and crop production performance achieved with the CAAP chamber, compared with current state-of-the-art, places plant-based life support systems at the threshold of feasibility. c2002 Published by Elsevier Science Ltd on behalf of COSPAR.

NLM

Antarctic Regions; Closed Ecological Systems; Crop Growth; Life Support Systems; Plants (Botany); Space Environment Simulation; Vegetables

20040087500

Adaptation of SUBSTOR for controlled-environment potato production with elevated carbon dioxide

Fleisher, D. H., Author; Cavazzoni, J., Author; Giacomelli, G. A., Author; Ting, K. C., Author; Janes, H. W., Principal Investigator; Transactions of the ASAE. American Society of Agricultural Engineers; Mar-Apr 2003; ISSN 0001-2351; Volume 46, Issue 2, 531-8; In English

Contract(s)/Grant(s): NGT5-50229; Copyright; Avail: Other Sources

The SUBSTOR crop growth model was adapted for controlled-environment hydroponic production of potato (Solanum tuberosum L. cv. Norland) under elevated atmospheric carbon dioxide concentration. Adaptations included adjustment of input files to account for cultural differences between the field and controlled environments, calibration of genetic coefficients, and adjustment of crop parameters including radiation use efficiency. Source code modifications were also performed to account for the absorption of light reflected from the surface below the crop canopy, an increased leaf senescence rate, a carbon (mass) balance to the model, and to modify the response of crop growth rate to elevated atmospheric carbon dioxide concentration. Adaptations were primarily based on growth and phenological data obtained from growth chamber experiments at Rutgers University (New Brunswick, N.J.) and from the modeling literature. Modified-SUBSTOR predictions were compared with data from Kennedy Space Center's Biomass Production Chamber for verification. Results show that, with further

development, modified-SUBSTOR will be a useful tool for analysis and optimization of potato growth in controlled environments.
NLM
Carbon Dioxide; Controlled Atmospheres; Environmental Control; Hydroponics; Models; Potatoes

20040092560

[Biological processes of the human environment regeneration within the Martian crew life support systems]
Sychev, V. N., Author; Levinskikh, M. A., Author; Shepelev, E. Ia, Author; Podol'skii, I. G., Author; Aviakosmicheskaia i ekologicheskaia meditsina = Aerospace and environmental medicine; 2003; ISSN 0233-528X; Volume 37, Issue 5, 64-70; In Belorussian; Copyright; Avail: Other Sources

Five ground-based experiments at RF SRC-IBMP had the purpose to make a thorough investigation of a model of the human-unicellular algae-mineralization life support system. The system measured 15 m3 and contained 45 liters of alga suspension; the dry alga density was 10 to 12 g/l and water volume (including the alga suspension) amounted to 59 l. More sophisticated LSS models where algae were substituted by higher plants (crop area in the greenhouse equaled 15 m2) were investigated in three experiments from 1.5 mos. to 2 mos. in duration. It was found that the alga containing LSS was able to fulfill not only the macrofunction (air and water regeneration) but also several additional functions (air purification, establishment of microbial cenosis etc.) providing an adequate human environment. This polyfunctionality of the biological regenerative processes is a weighty argument for their integration into space LSSs. Another important aspect is that the unicellular algae containing systems are highly reliable owing to a huge number of species-cells which will be quickly recovered in case of the death of a part of the population and, consequently, functionality of the LSS autotrophic component will be restored before long. For an extended period of time the Martian crew will have no communication with the Earth's biosphere which implies that LSS should be absolutely reliable and redundant. Redundancy can be achieved through installation aboard the vehicle of two systems constructed on different principles of regeneration, i.e. physical-chemical and biological. Each of the LSSs should have the power to satisfy all needs of the crew. The best option is when two systems are functioning in parallel sharing the responsibility for the human environment. Redundancy in this case will mean that in the event of failure or a drastic decrease in performance of one system the other one will make up for the loss by increasing its share in the overall regeneration process.
NLM
Activity (Biology); Closed Ecological Systems; Life Support Systems; Mars (Planet); Spacecrews

20040087854

Pigment composition and concentrations within the plant (Ceratophyllum demersum L.) component of the STS-89 C.E.B.A.S. Mini-Module spaceflight experiment
Voeste, D., Author; Levine, L. H., Author; Levine, H. G., Author; Blum, V., Author; Wheeler, R. M., Principal Investigator; Advances in space research : the official journal of the Committee on Space Research (COSPAR); 2003; Volume 31, Issue 1, 211-4; In English
Contract(s)/Grant(s): NAS10-12180; Copyright; Avail: Other Sources

The Closed Equilibrated Biological Aquatic System (C.E.B.A.S.) Mini-Module, a Space Shuttle middeck locker payload which supports a variety of aquatic inhabitants (fish, snails, plants and bacteria) in an enclosed 8.6 L chamber, was tested for its biological stability in microgravity. The aquatic plant, Ceratophyllum demersum L., was critical for the vitality and functioning of this artificial mini-ecosystem. Its photosynthetic pigment concentrations were of interest due to their light harvesting and protective functions. 'Post-flight' chlorophyll and carotenoid concentrations within Ceratophyllum apical segments were directly related to the quantities of light received in the experiments, with microgravity exposure (STS-89) failing to account for any significant deviation from ground control studies. Published by Elsevier Science Ltd on behalf of COSPAR.
NLM
Closed Ecological Systems; Life Support Systems; Metabolism; Pigments; Plants (Botany); Space Flight; Space Transportation System; Weightlessness

20040087474

The effect of drying and size reduction pretreatments on recovery of inorganic crop nutrients from inedible wheat residues
Strayer, R. F., Author; Alazraki, M. P., Author; Judkins, J., Author; Habitation (Elmsford, N.Y.); 2003; ISSN 1542-9660; Volume 9, Issue 1-2, 1-8; In English
Contract(s)/Grant(s): NAS9-98126; Copyright; Avail: Other Sources

Inorganic nutrients can be easily recovered from ALS crop residue solid wastes by aqueous leaching. However, oven drying and milling pretreatment of these residues has been frequently required to accommodate crop scientists and facility storage limitations. As part of a research study that will compare three different bioreactor technologies for processing these wastes, we realized that different drying and size-reduction pretreatments had been utilized for each technology. This paper compares the effects of residue pretreatment on recovery of nutrients by leaching. Pretreatments included three drying methods [fresh, oven-dried (70 degrees C overnight), and freeze-dried] and two size reduction methods [chopped (2 cm length) and milled (2 mm diameter)]. Determination of mass balances (dry weight and ash content of solids) before and after leaching indicated solubilization was least for fresh residues (23% dry weight loss and 50% for ash loss), and most for freeze-dried residues (41-47% dry weight loss and nearly 100% for ash loss). Mineral recovery of major elements (NO3, PO4, K, Ca, and Mg) in leachates was poorest for fresh residues. P and K recovery in leachates were best for oven-dried residues and Ca, Mg, and N recovery best for freeze-dried residues. The differences in recovery for N, P, and K in leachates were minimal between chopping and milling and slightly better for Ca and Mg from milled residues.
NLM
Biomass; Bioreactors; Drying; Farm Crops; Minerals; Pretreatment; Residues; Waste Management; Wheat

20040087473

Work measurement for estimating food preparation time of a bioregenerative diet

Olabi, Ammar, Author; Hunter, Jean, Author; Jackson, Peter, Author; Segal, Michele, Author; Spies, Rupert, Author; Wang, Carolyn, Author; Lau, Christina, Author; Ong, Christopher, Author; Alexander, Conor, Author; Raskob, Evan, Author; Plichta, Jennifer, Author; Zeira, Ohad, Author; Rivera, Randy, Author; Wang, Susan, Author; Pottle, Bill, Author; Leung, Calvin, Author; Vicens, Carrie, Author; Tao, Christine, Author; Beers, Craig, Author; Fung, Grace, Author; Levine, Jacob, Author; Yoo, Jaeshin, Author; Jackson, Joanna, Author; Saikkonen, Kelly, Author; Zimmerman, Matthew, Author, et al.; Habitation (Elmsford, N.Y.); 2003; ISSN 1542-9660; Volume 9, Issue 1-2, 17-30; In English
Contract(s)/Grant(s): NAG5-4222; Copyright; Avail: Other Sources

During space missions, such as the prospective Mars mission, crew labor time is a strictly limited resource. The diet for such a mission (based on crops grown in a bioregenerative life support system) will require astronauts to prepare their meals essentially from raw ingredients. Time spent on food processing and preparation is time lost for other purposes. Recipe design and diet planning for a space mission should therefore incorporate the time required to prepare the recipes as a critical factor. In this study, videotape analysis of an experienced chef was used to develop a database of recipe preparation time. The measurements were highly consistent among different measurement teams. Data analysis revealed a wide variation between the active times of different recipes, underscoring the need for optimization of diet planning. Potential uses of the database developed in this study are discussed and illustrated in this work.
NLM
Closed Ecological Systems; Diets; Estimating; Food; Life Support Systems; Regeneration (Physiology); Work

20040087472

Optimized bioregenerative space diet selection with crew choice

Vicens, Carrie, Author; Wang, Carolyn, Author; Olabi, Ammar, Author; Jackson, Peter, Author; Hunter, Jean, Author; Habitation (Elmsford, N.Y.); 2003; ISSN 1542-9660; Volume 9, Issue 1-2, 31-9; In English
Contract(s)/Grant(s): NAG5-4222; Copyright; Avail: Other Sources

Previous studies on optimization of crew diets have not accounted for choice. A diet selection model with crew choice was developed. Scenario analyses were conducted to assess the feasibility and cost of certain crew preferences, such as preferences for numerous-desserts, high-salt, and high-acceptability foods. For comparison purposes, a no-choice and a random-choice scenario were considered. The model was found to be feasible in terms of food variety and overall costs. The numerous-desserts, high-acceptability, and random-choice scenarios all resulted in feasible solutions costing between 13.2 and 17.3 kg ESM/person-day. Only the high-sodium scenario yielded an infeasible solution. This occurred when the foods highest in salt content were selected for the crew-choice portion of the diet. This infeasibility can be avoided by limiting the total sodium content in the crew-choice portion of the diet. Cost savings were found by reducing food variety in scenarios where the preference bias strongly affected nutritional content.
NLM
Diets; Eating; Models; Regeneration (Physiology); Selection

20040087441

The use of rice hulls for sustainable control of NOx emissions in deep space missions

Xu, X. H., Author; Shi, Y., Author; Kwak, D., Author; Chang, S. G., Author; Fisher, J. W., Author; Pisharody, S., Author; Moran, M. J., Author; Wignarajah, K., Author; Industrial & engineering chemistry research; Apr 16 2003; ISSN 0888-5885; Volume 42, Issue 8, 1813-20; In English; Copyright; Avail: Other Sources

The use of the activated carbon produced from rice hulls to control NOx emissions for future deep space missions has been demonstrated. The optimal carbonization temperature range was found to be between 600 and 750 degrees C. A burnoff of 61.8% was found at 700 degrees C in pyrolysis and 750 degrees C in activation. The BET surface area of the activated carbon from rice hulls was determined to be 172 m2/g when prepared at 700 degrees C. The presence of oxygen in flue gas is essential for effective adsorption of NO by activated carbon. On the contrary, water vapor inhibits the adsorption efficiency of NO. Consequently, water vapor in flue gas should be removed by drying agents before adsorption to ensure high NO adsorption efficiency. All of the NO in the flue gas was removed for more than 1.5 h when 10% oxygen was present and the ratio of the carbon weight to the flue gas flow rate (W/F) was 15.4 g min/L. Reduction of the adsorbed NO to form N2 could be effectively accomplished under anaerobic conditions at 550 degrees C. The adsorption capacity of NO on the activated carbon was found to be 5.02 mg of NO/g of carbon. The loss of carbon mass was determined to be about 0.16% of the activated carbon per cycle of regeneration if the regeneration occurred when the NO in the flue gas after the carbon bed reached 4.8 ppm, the space maximum allowable concentration. The reduction of the adsorbed NO also regenerated the activated carbon, and the regenerated activated carbon exhibited an improved NO adsorption efficiency.

NLM

Charcoal; Closed Ecological Systems; Deep Space; Hulls (Structures); Life Support Systems; Nitric Oxide; Nitrogen Oxides; Rice; Space Missions; Spacecraft Control

20040087440

Method for the control of NOx emissions in long-range space travel

Xu, X. H., Author; Shi, Y., Author; Liu, S. H., Author; Wang, H. P., Author; Chang, S. G., Author; Fisher, J. W., Author; Pisharody, S., Author; Moran, M., Author; Wignarajah, K., Author; Energy & fuels : an American Chemical Society journal; Sep-Oct 2003; ISSN 0887-0624; Volume 17, Issue 5, 1303-10; In English; Copyright; Avail: Other Sources

The wheat straw, an inedible biomass that can be continuously produced in a space vehicle has been used to produce activated carbon for effective control of NOx emissions from the incineration of wastes. The optimal carbonization temperature of wheat straw was found to be around 600 degrees C when a burnoff of 67% was observed. The BET surface area of the activated carbon produced from the wheat straw reached as high as 300 m2/g. The presence of oxygen in flue gas is essential for effective adsorption of NO by activated carbon. On the contrary, water vapor inhibits the adsorption efficiency of NO. Consequently, water vapor in flue gas should be removed by drying agents before adsorption to ensure high NO adsorption efficiency. All of the NO in the flue gas was removed for more than 2 h by the activated carbons when 10% oxygen was present and the ratio of carbon weight to the flue gas flow rate (W/F) was 30 g min/L, with a contact time of 10.2 s. All of NO was reduced to N2 by the activated carbon at 450 degrees C with a W/F ratio of 15 g min/L and a contact time of 5.1 s. Reduction of the adsorbed NO also regenerated the activated carbon, and the regenerated activated carbon exhibited an improved NO adsorption efficiency. However, the reduction of the adsorbed NO resulted in a loss of carbon which was determined to be about 0.99% of the activated carbon per cycle of regeneration. The sufficiency of the amount of wheat straw in providing the activated carbon based on a six-person crew, such as the mission planned for Mars, has been determined. This novel approach for the control of NOx emissions is sustainable in a closed system such as the case in space travel. It is simple to operate and is functional under microgravity environment.

NLM

Charcoal; Closed Ecological Systems; Life Support Systems; Nitric Oxide; Nitrogen Oxides; Spacecraft Control; Wheat

20040087414

Mineralogical and chemical characterization of iron-, manganese-, and copper-containing synthetic hydroxyapatites

Sutter, B., Author; Ming, D. W., Author; Clearfield, A., Author; Hossner, L. R., Author; Soil Science Society of America journal. Soil Science Society of America; Nov-Dec 2003; ISSN 0361-5995; Volume 67, Issue 6, 1935-42; In English
Contract(s)/Grant(s): NGT5-1229; Copyright; Avail: Other Sources

The National Aeronautics and Space Administration's (NASA) Advanced Life Support (ALS) Program is evaluating the use of Fe-, Mn-, and Cu-containing synthetic hydroxyapatite (SHA) as a slow release fertilizer for crops that might be grown on the International Space Station or at Lunar and Martian outposts. Separate Fe-, Mn-, and Cu-containing SHA materials along with a transition-metal free SHA (pure-SHA) were synthesized using a precipitation method. Chemical and mineralogical analyses determined if and how Fe, Mn, and Cu were incorporated into the SHA structure. X-ray diffraction (XRD), Rietveld refinement, and transmission electron microscopy (TEM) confirmed that SHA materials with the apatite structure were produced. Chemical analyses indicated that the metal containing SHA materials were deficient in Ca relative to pure-SHA. The shift in the infrared PO4-mu 3 vibrations, smaller unit cell parameters, smaller particle size, and greater structural strain for Fe-, Mn-, and Cu-containing SHA compared with pure-SHA suggested that Fe, Mn, and Cu were incorporated into SHA structure. Rietveld analyses revealed that Fe, Mn, and Cu substituted into the Ca2 site of SHA. An Fe-rich phase was detected by TEM analyses and backscattered electron microscopy in the Fe-containing SHA material with the greatest Fe content. The substitution of metals into SHA suggests that metal-SHA materials are potential slow-release sources of micronutrients for plant uptake in addition to Ca and P.

NLM

Calcium Phosphates; Closed Ecological Systems; Copper; Culture Media; Fertilizers; Iron; Life Support Systems; Manganese; Mineralogy; Minerals

20040087407

Porous cobalt spheres for high temperature gradient magnetically assisted fluidized beds

Atwater, James E., Author; Akse, James R., Author; Jovanovic, Goran N., Author; Wheeler, Richard R Jr, Author; Sornchamni, Thana, Author; Materials research bulletin; Feb 20 2003; ISSN 0025-5408; Volume 38, Issue 3, 395-407; In English

Contract(s)/Grant(s): NAG9-1181; Copyright; Avail: Other Sources

Porous metallic cobalt spheres have been prepared as high temperature capable media for employment in gradient magnetically assisted fluidization and filtration technologies. Cobalt impregnated alginate beads are first formed by extrusion of an aqueous suspension of Co3O4 into a Co(II) chloride solution. The organic polymer is thermally decomposed yielding cobalt oxide spheres, followed by reduction to the metallic state, and densification. Cobalt beads have been produced with porosities ranging between 10 and 50%, depending upon sintering conditions. The product media have been characterized by scanning electron microscopy (SEM), nitrogen adsorption porosimetry, and vibrating sample magnetometry.

NLM

Closed Ecological Systems; Cobalt; Fluidized Bed Processors; High Temperature; Life Support Systems; Magnetic Properties; Porosity; Spheres; Temperature Gradients

20040087858

Farming in space: environmental and biophysical concerns

Monje, O., Author; Stutte, G. W., Author; Goins, G. D., Author; Porterfield, D. M., Author; Bingham, G. E., Author; Advances in space research : the official journal of the Committee on Space Research (COSPAR); 2003; Volume 31, Issue 1, 151-67; In English

Contract(s)/Grant(s): NCC10-0027; Copyright; Avail: Other Sources

The colonization of space will depend on our ability to routinely provide for the metabolic needs (oxygen, water, and food) of a crew with minimal re-supply from Earth. On Earth, these functions are facilitated by the cultivation of plant crops, thus it is important to develop plant-based food production systems to sustain the presence of mankind in space. Farming practices on earth have evolved for thousands of years to meet both the demands of an ever-increasing population and the availability of scarce resources, and now these practices must adapt to accommodate the effects of global warming. Similar challenges are expected when earth-based agricultural practices are adapted for space-based agriculture. A key variable in space is gravity; planets (e.g. Mars, 1/3 g) and moons (e.g. Earth's moon, 1/6 g) differ from spacecraft orbiting the Earth (e.g. Space stations) or orbital transfer vehicles that are subject to microgravity. The movement of heat, water vapor, CO2 and O2 between plant surfaces and their environment is also affected by gravity. In microgravity, these processes may also be affected by reduced mass transport and thicker boundary layers around plant organs caused by the absence of buoyancy dependent convective transport. Future space farmers will have to adapt their practices to accommodate microgravity, high and low extremes in ambient temperatures, reduced atmospheric pressures, atmospheres containing high volatile organic carbon contents, and elevated to super-elevated CO2 concentrations. Farming in space must also be carried out within power-, volume-, and mass-limited life support systems and must share resources with manned crews. Improved lighting and sensor technologies will have to be developed and tested for use in space. These developments should also help make crop production in terrestrial controlled environments (plant growth chambers and greenhouses) more efficient and, therefore, make these

alternative agricultural systems more economically feasible food production systems. c2002 COSPAR. Published by Elsevier Science Ltd. All rights reserved.
NLM
Agriculture; Biophysics; Closed Ecological Systems; Life Support Systems; Plant Roots; Weightlessness

20040087857

Carbon balance in bioregenerative life support systems: some effects of system closure, waste management, and crop harvest index

Wheeler, Raymond M., Author; Advances in space research : the official journal of the Committee on Space Research (COSPAR); 2003; Volume 31, Issue 1, 169-75; In English; Copyright; Avail: Other Sources

In Advanced Life Support (ALS) systems with bioregenerative components, plant photosynthesis would be used to produce O2 and food, while removing CO2. Much of the plant biomass would be inedible and hence must be considered in waste management. This waste could be oxidized (e.g., incinerated or aerobically digested) to resupply CO2 to the plants, but this would not be needed unless the system were highly closed with regard to food. For example, in a partially closed system where some of the food is grown and some is imported, CO2 from oxidized waste when combined with crew and microbial respiration could exceed the CO2 removal capability of the plants. Moreover, it would consume some O2 produced from photosynthesis that could have been used by the crew. For partially closed systems it would be more appropriate to store or find other uses for the inedible biomass and excess carbon, such as generating soils or growing woody plants (e.g., dwarf fruit trees). Regardless of system closure, high harvest crops (i.e., crops with a high edible to total biomass ratio) would increase food production per unit area and O2 yields for systems where waste biomass is oxidized to recycle CO2. Such interlinking effects between the plants and waste treatment strategies point out the importance of oxidizing only that amount of waste needed to optimize system performance. Published by Elsevier Science Ltd on behalf of COSPAR.
NLM
Biomass; Carbon; Closed Ecological Systems; Farm Crops; Life Support Systems; Plants (Botany); Regeneration (Physiology); Waste Management

20040087482

Electronic nose for space program applications

Young, Rebecca C., Author; Buttner, William J., Author; Linnell, Bruce R., Author; Ramesham, Rajeshuni, Author; Sensors and actuators. B, Chemical; Aug 1 2003; ISSN 0925-4005; Volume 93, Issue 1-3, 7-16; In English; Copyright; Avail: Other Sources

The ability to monitor air contaminants in the shuttle and the International Space Station is important to ensure the health and safety of astronauts, and equipment integrity. Three specific space applications have been identified that would benefit from a chemical monitor: (a) organic contaminants in space cabin air; (b) hypergolic propellant contaminants in the shuttle airlock; (c) pre-combustion signature vapors from electrical fires. NASA at Kennedy Space Center (KSC) is assessing several commercial and developing electronic noses (E-noses) for these applications. A short series of tests identified those E-noses that exhibited sufficient sensitivity to the vapors of interest. Only two E-noses exhibited sufficient sensitivity for hypergolic fuels at the required levels, while several commercial E-noses showed sufficient sensitivity of common organic vapors. These E-noses were subjected to further tests to assess their ability to identify vapors. Development and testing of E-nose models using vendor supplied software packages correctly identified vapors with an accuracy of 70-90%. In-house software improvements increased the identification rates between 90 and 100%. Further software enhancements are under development. Details on the experimental setup, test protocols, and results on E-nose performance are presented in this paper along with special emphasis on specific software enhancements. c2003 Elsevier Science B.V. All rights reserved.
NLM
Air Pollution; Environmental Monitoring; Gases; Indoor Air Pollution; Life Support Systems; Space Programs

20040105523

Space life sciences: missions to Mars, radiation biology, and plants as a foundation for long-term life support systems in space. Refereed papers from the F0.1 and F1.3-F2.3 Symposia of COSPAR Scientific Commission F which were held during the Thirty-third COSPAR Scientific Assembly, Warsaw, Poland, July 2000

Advances in space research : the official journal of the Committee on Space Research (COSPAR); 2003; Volume 31, Issue 1, v-vii, 1-272; In English; Copyright; Avail: Other Sources

No abstract available
Closed Ecological Systems; Life Support Systems; Mars (Planet); Mars Missions; Plants (Botany); Poland; Radiation Effects; Radiobiology; Space Missions; Weightlessness

20040087849

Biodegradation pathway of an anionic surfactant (Igepon TC-42) during recycling waste water through plant hydroponics for advanced life support during long-duration space missions

Levine, L. H., Author; Kagie, H. R., Author; Garland, J. L., Author; Advances in space research : the official journal of the Committee on Space Research (COSPAR); 2003; Volume 31, Issue 1, 249-53; In English

Contract(s)/Grant(s): NAS10-12180; Copyright; Avail: Other Sources

The degradation of an anionic surfactant (Igepon TC-42) was investigated as part of an integrated study of direct recycling of human hygiene water through hydroponic plant growth systems. Several chemical approaches were developed to characterize the degradation of Igepon and to measure the accumulation of intermediates such as fatty acids and methyl taurine. Igepon was rapidly degraded as indicated by the reduction of methylene blue active substances (MBAS) and component fatty acids. The Igepon degradation rate continued to increase over a period of several weeks following repeated daily exposure to 18 micrograms/l Igepon. The accumulation of free fatty acids and methyl taurine was also observed during decomposition of Igepon. The concentration of methyl taurine was below detection limit (0.2 nmol/ml) during the slow phase of Igepon degradation, and increased to 1-2 nmol/ml during the phase of rapid degradation. These findings support a degradation pathway involving initial hydrolysis of amide to release fatty acids and methyl taurine, and subsequent degradation of these intermediates. Published by Elsevier Science Ltd on behalf of COSPAR.

NLM

Anions; Biodegradation; Closed Ecological Systems; Hydroponics; Life Support Systems; Liquid Wastes; Long Duration Space Flight; Negative Ions; Recycling; Surfactants; Waste Disposal; Waste Water

20040043717 Science Applications International Corp., Huntsville, AL, USA

Integrated Testing of a Carbon Dioxide Removal Assembly and a Temperature-Swing Adsorption Compressor for Closed-Loop Air Revitalization

Knox, J. C.; Mulloth, Lila; Frederick, Kenneth; Affleck, Dave; [2003]; In English, 19-22 Jul. 2004, Colorado Springs, CO, USA

Contract(s)/Grant(s): 131-20-10; No Copyright; Avail: Other Sources; Abstract Only

Accumulation and subsequent compression of carbon dioxide that is removed from space cabin are two important processes involved in a closed-loop air revitalization scheme of the International Space Station (ISS). The carbon dioxide removal assembly (CDRA) of ISS currently operates in an open loop mode without a compressor. This paper describes the integrated test results of a flight-like CDRA and a temperature-swing adsorption compressor (TSAC) for carbon dioxide removal and compression. The paper provides details of the TSAC operation at various CO2 loadings and corresponding performance of CDRA.

Author

Carbon Dioxide Removal; Adsorption; Air Purification

20040033988 Institute of Space Medico-Engineering, Beijing, China

Physical Simulation of Human Body Metabolism in Sealed Module on the Ground

Tu, Bo; Lin, Gui-Ping; Rui, Jia-Bai; Space Medicine and Medical Engineering, Volume 16, No. 2; April 2003, 128-132; In Chinese; Copyright; Avail: Other Sources

The objective of this investigation was to provide a test platform for experimental verification of environmental control and life support systems of manned spacecraft on the ground. Simulation of human body metabolism was divided into different units, and a ground simulator was designed.

Author (revised)

Life Support Systems; Simulators; Metabolism

20040093782

Carbon dioxide scrubbing capabilities of two new nonpowered technologies

Norfleet, William, Author; Horn, Wayne, Author; Habitation (Elmsford, N.Y.); 2003; ISSN 1542-9660; Volume 9, Issue 1-2, 67-78; In English; Copyright; Avail: Other Sources

Current guidance for survivors aboard a disabled submarine (DISSUB) recommends the use of the ‘stir-and-fan’ method of carbon dioxide (CO2) scrubbing in which the contents of canisters of lithium hydroxide (LiOH) are dispersed onto horizontal surfaces. This technique is objectionable because it releases large quantities of fine, caustic LiOH dust and it utilizes LiOH inefficiently. This report presents the results of laboratory studies of the CO2 scrubbing capabilities of two new products

that might improve on ‘stir-and-fan’: the Battelle Curtain (BC) and the Micropore Reactive Plastic Curtain (RPC). Experiments took place within a sealed hyperbaric chamber. CO2 was added to the chamber at a known mass flow that reproduced what might be encountered in a ‘worst-case’ DISSUB scenario. Natural convection alone circulated gas within the chamber. The mass of BCs or RPCs necessary to limit CO2 to 3% for about 2 days was determined. The total scrubbing capacity (mass of CO2 scrubbed per unit mass of agent) of the BC was 0.756 +/- 0.012 (mean +/- SD), and the comparable value for the RPC was 0.808 +/- 0.007. Both products provided a scrubbing capacity that is close to the stoichiometric limit of the reaction (0.919). Neither product released sufficient caustic dust to prevent handling by a trained individual wearing no personal protective equipment.
NLM
Air Conditioning; Carbon Dioxide; Closed Ecological Systems; Life Support Systems; Lithium Compounds; Washing

20040102968

Recycling efficiencies of C, H, O, N, S, and P elements in a Biological Life Support System based on microorganisms and higher plants

Gros, J. B., Author; Poughon, L., Author; Lasseur, C., Author; Tikhomirov, A. A., Author; Advances in space research : the official journal of the Committee on Space Research (COSPAR); 2003; Volume 31, Issue 1, 195-9; In English; Copyright; Avail: Other Sources

MELiSSA is a microorganism based artificial ecosystem conceived as a tool for understanding the behavior of ecosystems and developing the technology for future Manned Space Missions. MELiSSA is composed of four compartments colonized by the microorganisms required by the function of this ecosystem : breakdown of waste produced by men, regeneration of atmosphere and biosynthesis of edible biomass. This paper reports the mass balance description of a Biological Life Support System composed of the MELiSSA loop and of a Higher Plant Compartment working in parallel with the photosynthetic Spirulina compartment producing edible biomass. The recycling efficiencies of the system are determined and compared for various working conditions of the MELiSSA loop with or without the HPC. c2002 Published by Elsevier Science Ltd on behalf of COSPAR.
NLM
Biomass; Closed Ecological Systems; Efficiency; Life Sciences; Life Support Systems; Microorganisms; Models; Recycling; Waste Management

20030006893

Operation, Modeling and Analysis of the Reverse Water Gas Shift Process

Whitlow, Jonathan E.; Parrish, Clyde F.; AIP Conference Proceedings; January 28, 2003; ISSN 0094-243X; Volume 654, Issue no. 1, 1116-1123; In English; SPACE TECHNOLOGY and APPLICATIONS INT.FORUM-STAIF 2003: Conf.on Thermophysics in Microgravity; Commercial/Civil Next Generation Space Transportation; Human Space Exploration, 2-5 February 2003, Albuquerque, New Mexico, USA; Copyright

The Reverse Water Gas Shift (RWGS) process is a candidate technology for water and oxygen production on Mars as part of the In-Situ Space Resource Utilization (ISRU) initiative. This paper focuses on the operation and analysis of the RWGS process, which has been constructed and operated at Kennedy Space Center. While the investigation of the RWGS process is on-going, a summary of results obtained from the operation to date is presented. In addition, simulation models of the RWGS process have been developed and description of the models is also included. [copyright] 2003 American Institute of Physics
Author (AIP)
Mars (Planet); Oxygen; Oxygen Production; Water

20040103025

Development and research program for a soil-based bioregenerative agriculture system to feed a four person crew at a Mars base

Silverstone, S., Author; Nelson, M., Author; Alling, A., Author; Allen, J., Author; Advances in space research : the official journal of the Committee on Space Research (COSPAR); 2003; Volume 31, Issue 1, 69-75; In English; Copyright; Avail: Other Sources

For humans to survive during long-term missions on the Martian surface, bioregenerative life support systems including food production will decrease requirements for launch of Earth supplies, and increase mission safety. It is proposed that the development of ‘modular biospheres’--closed system units that can be air-locked together and which contain soil-based bioregenerative agriculture, horticulture, with a wetland wastewater treatment system is an approach for Mars habitation

scenarios. Based on previous work done in long-term life support at Biosphere 2 and other closed ecological systems, this consortium proposes a research and development program called Mars On Earth(TM) which will simulate a life support system designed for a four person crew. The structure will consist of 6 x 110 square meter modular agricultural units designed to produce a nutritionally adequate diet for 4 people, recycling all air, water and waste, while utilizing a soil created by the organic enrichment and modification of Mars simulant soils. Further research needs are discussed, such as determining optimal light levels for growth of the necessary range of crops, energy trade-offs for agriculture (e.g. light intensity vs. required area), capabilities of Martian soils and their need for enrichment and elimination of oxides, strategies for use of human waste products, and maintaining atmospheric balance between people, plants and soils. c2002 COSPAR. Published by Elsevier Science Ltd. All rights reserved.
NLM
Agriculture; Closed Ecological Systems; Life Support Systems; Mars (Planet); Plants (Botany); Regeneration (Physiology); Soils

20040103024

Possible applications of aquatic bioregenerative life support modules for food production in a Martian base

Bluem, V., Author; Paris, F., Author; Advances in space research : the official journal of the Committee on Space Research (COSPAR); 2003; Volume 31, Issue 1, 77-86; In English; Copyright; Avail: Other Sources

Water is the essential precondition of life in general and also for the establishment of a Martian base suitable for long duration stays of humans. It is not yet proven if there is indeed a 'frozen ocean' under the surface of Mars but if this could be verified it would open innovative aspects for the construction of bioregenerative life support systems (BLSS). In a general concept higher plants will play the predominant role in a Martian BLSS. It is not clear, however, how these will grow and bring seed in reduced gravity and there may be differences in the productivity in comparison to Earth conditions. Therefore, organisms which are already adapted to low gravity conditions, namely non-gravitropic aquatic plants and also aquatic animals may be used to enhance the functionality of the Martian BLSS as a whole. It has been shown already with the so-called C.E.B.A.S. MINIMODULE in the STS-89 and STS-90 spaceshuttle missions that the water plant Ceratophyllum demersum has an undisturbed and high biomass production under space conditions. Moreover, the teleost fish species Xiphophorus helleri adapted easily to the micro-g environment and maintained its normal reproductive functions. Based on this findings a possible scenario is presented in which aquatic plant production modules and combined animal-plant production systems may be used for human food production and water and air regeneration in a Martian base. c2002 COSPAR. Published by Elsevier Science Ltd. All rights reserved.
NLM
Aquiculture; Closed Ecological Systems; Food; Life Support Systems; Marine Biology; Mars (Planet); Modules; Organisms; Regeneration (Physiology)

20040103018

Effects of air current speed on gas exchange in plant leaves and plant canopies

Kitaya, Y., Author; Tsuruyama, J., Author; Shibuya, T., Author; Yoshida, M., Author; Kiyota, M., Author; Advances in space research : the official journal of the Committee on Space Research (COSPAR); 2003; Volume 31, Issue 1, 177-82; In English; Copyright; Avail: Other Sources

To obtain basic data on adequate air circulation to enhance plant growth in a closed plant culture system in a controlled ecological life support system (CELSS), an investigation was made of the effects of the air current speed ranging from 0.01 to 1.0 m s-1 on photosynthesis and transpiration in sweetpotato leaves and photosynthesis in tomato seedlings canopies. The gas exchange rates in leaves and canopies were determined by using a chamber method with an infrared gas analyzer. The net photosynthetic rate and the transpiration rate increased significantly as the air current speeds increased from 0.01 to 0.2 m s-1. The transpiration rate increased gradually at air current speeds ranging from 0.2 to 1.0 m s-1 while the net photosynthetic rate was almost constant at air current speeds ranging from 0.5 to 1.0 m s-1. The increase in the net photosynthetic and transpiration rates were strongly dependent on decreased boundary-layer resistances against gas diffusion. The net photosynthetic rate of the plant canopy was doubled by an increased air current speed from 0.1 to 1.0 m s-1 above the plant canopy. The results demonstrate the importance of air movement around plants for enhancing the gas exchange in the leaf, especially in plant canopies in the CELSS. c2002 COSPAR. Published by Elsevier Science Ltd. All rights reserved.
NLM
Air Currents; Canopies (Vegetation); Closed Ecological Systems; Gas Exchange; Leaves; Life Support Systems; Metabolism; Photosynthesis; Plant Physiology; Transpiration

20040096104

Effects of CO2 concentration and light intensity on photosynthesis of a rootless submerged plant, Ceratophyllum demersum L., used for aquatic food production in bioregenerative life support systems

Kitaya, Y., Author; Okayama, T., Author; Murakami, K., Author; Takeuchi, T., Author; Advances in space research : the official journal of the Committee on Space Research (COSPAR); 2003; Volume 31, Issue 7, 1743-9; In English; Copyright; Avail: Other Sources

In addition to green microalgae, aquatic higher plants are likely to play an important role in aquatic food production modules in bioregenerative systems for producing feed for fish, converting CO2 to O2 and remedying water quality. In the present study, the effects of culture conditions on the net photosynthetic rate of a rootless submerged plant, Ceratophyllum demersum L., was investigated to determine the optimum culture conditions for maximal function of plants in food production modules including both aquatic plant culture and fish culture systems. The net photosynthetic rate in plants was determined by the increase in dissolved O2 concentrations in a closed vessel containing a plantlet and water. The water in the vessel was aerated sufficiently with a gas containing a known concentration of CO2 gas mixed with N2 gas before closing the vessel. The CO2 concentrations in the aerating gas ranged from 0.3 to 10 mmol mol-1. Photosynthetic photon flux density (PPFD) in the vessel ranged from 0 (dark) to 1.0 mmol m-2 s-1, which was controlled with a metal halide lamp. Temperature was kept at 28 degrees C. The net photosynthetic rate increased with increasing PPFD levels and was saturated at 0.2 and 0.5 mmol m-2 s-1 PPFD under CO2 levels of 1.0 and 3.0 mmol mol-1, respectively. The net photosynthetic rate increased with increasing CO2 levels from 0.3 to 3.0 mmol mol-1 showing the maximum value, 75 nmol O2 gDW-1 s-1, at 2-3 mmol mol-1 CO2 and gradually decreased with increasing CO2 levels from 3.0 to 10 mmol mol-1. The results demonstrate that C. demersum could be an efficient CO2 to O2 converter under a 2.0 mmol mol-1 CO2 level and relatively low PPFD levels in aquatic food production modules. c2003 COSPAR. Published by Elsevier Science Ltd. All rights reserved.

NLM

Carbon Dioxide; Carbon Dioxide Concentration; Closed Ecological Systems; Life Support Systems; Light (Visible Radiation); Luminous Intensity; Photosynthesis; Plants (Botany)

20040092442

Habitation 2004 Conference abstracts, January 4-7, 2004, Orlando, FL

Habitation (Elmsford, N.Y.); 2003; ISSN 1542-9660; Volume 9, Issue 3-4, 89-218; In English; Copyright; Avail: Other Sources

This issue contains abstracts from the Habitation 2004 Conference, held January 4-7, 2004. Abstracts are presented in four topic areas: Human Life Support; Human Factors and Ergonomics; Monitoring and Control; and Others, which includes the uses of plants in spacecraft, education programs, and spacecraft design issues.

NASA

Abstracts; Closed Ecological Systems; Conferences; Life Support Systems; Weightlessness

20030065890 NASA Marshall Space Flight Center, Huntsville, AL, USA

Status of the Node 3 Regenerative Environmental Control & Life Support System Water Recovery & Oxygen Generation Systems

Carrasquillo, Robyn L.; January 2003; In English, 7-11 Jul. 2003, Vancouver, British Columbia, Canada

Report No.(s): Rept-2003-01-2590; Copyright; Avail: CASI; A03, Hardcopy

NASA s Marshall Space Flight Center is providing three racks containing regenerative water recovery and oxygen generation systems (WRS and OGS) for flight on the lnternational Space Station s (ISS) Node 3 element. The major assemblies included in these racks are the Water Processor Assembly (WPA), Urine Processor Assembly (UPA), Oxygen Generation Assembly (OGA), and the Power Supply Module (PSM) supporting the OGA. The WPA and OGA are provided by Hamilton Sundstrand Space Systems lnternational (HSSSI), while the UPA and PSM are being designed and manufactured in-house by MSFC. The assemblies are currently in the manufacturing and test phase and are to be completed and integrated into flight racks this year. This paper gives an overview of the technologies and system designs, technical challenges encountered and solved, and the current status.

Author

Life Support Systems; Oxygen Production; Water Reclamation; Waste Treatment; International Space Station

20040093784

Removal of sodium chloride from human urine via batch recirculation electrodialysis at constant applied voltage

Gordils-Striker, Nilda E., Author; Colon, Guillermo, Author; Habitation (Elmsford, N.Y.); 2003; ISSN 1542-9660; Volume 9, Issue 1-2, 47-57; In English

Contract(s)/Grant(s): NAG10-0257; Copyright; Avail: Other Sources

The removal of sodium chloride (NaCl) from human urine using a six-compartment electrodialysis cell with batch recirculation mode of operation for use in advanced life support systems (ALSS) was studied. From the results obtained, batch recirculation at constant applied voltage yields high values (approximately 94% of NaCl removal. Based on the results, the initial rate of NaCl removal was correlated to a power function of the applied voltage: -r=2.0 x 10(-4)E(3.8). With impedance spectroscopy methods, it was also found that the anion membranes were more affected by fouling with an increase of the ohmic resistance of almost 11% compared with 7.4% for the cationic ones.

NLM

Circulation; Closed Ecological Systems; Dialysis; Electric Potential; Electrochemistry; Electrodialysis; Liquid Wastes; Sodium Chlorides; Urine; Waste Disposal

20040093783

Development of a root feeding system based on a fiber ion-exchange substrate for space plant growth chamber 'Vitacycle'

Berkovich, Yu A., Author; Krivobok, N. M., Author; Krivobok, S. M., Author; Matusevich, V. V., Author; Soldatov, V. S., Author; Habitation (Elmsford, N.Y.); 2003; ISSN 1542-9660; Volume 9, Issue 1-2, 59-65; In English; Copyright; Avail: Other Sources

Selecting a plant root nutrient delivery system is one of the key aspects of designing root modules for space plant growth chambers. This article examines a number of the nutrient delivery systems and shows the most suitable technique for providing nutrients to roots in microgravity, which to date are ion-exchange artificial soils. In addition, this article characterizes the ion composition and hydrophysical parameters of a new Russian artificial ion charged fiber substrate, BIONA-V3. The BIONA-V3 substrate is comprised of ion-exchange resin fibers. The experimental data concerning the effects of anionic and cationic components on plant biomass is presented. Preliminary experiments with BIONA-V3 showed that 1 kg of dry BIONA-V3 produces up to 2.4 kg (fresh mass) of cabbage leaf or 180 g of dry plant mass per 1 dm3 of the substrate. Therefore, the root zone volume can be as small as 120 cm3 per plant. Further optimizing the nutrient composition of the resin fibers can increase space plant growth chamber productivity.

NLM

Culture Media; Ion Exchanging; Phytotrons; Plant Roots; Substrates; Vegetation Growth; Weightlessness

20040092942

HUMEX, a study on the survivability and adaptation of humans to long-duration exploratory missions, part I: lunar missions

Horneck, G., Author; Facius, R., Author; Reichert, M., Author; Rettberg, P., Author; Seboldt, W., Author; Manzey, D., Author; Comet, B., Author; Maillet, A., Author; Preiss, H., Author; Schauer, L., Author; Dussap, C. G., Author; Poughon, L., Author; Belyavin, A., Author; Reitz, G., Author; Baumstark-Khan, C., Author; Gerzer, R., Author; Advances in space research : the official journal of the Committee on Space Research (COSPAR); 2003; Volume 31, Issue 11, 2389-401; In English; Copyright; Avail: Other Sources

The European Space Agency has recently initiated a study of the human responses, limits and needs with regard to the stress environments of interplanetary and planetary missions. Emphasis has been laid on human health and performance care as well as advanced life support developments including bioregenerative life support systems and environmental monitoring. The overall study goals were as follows: (i) to define reference scenarios for a European participation in human exploration and to estimate their influence on the life sciences and life support requirements; (ii) for selected mission scenarios, to critically assess the limiting factors for human health, wellbeing, and performance and to recommend relevant countermeasures; (iii) for selected mission scenarios, to critically assess the potential of advanced life support developments and to propose a European strategy including terrestrial applications; (iv) to critically assess the feasibility of existing facilities and technologies on ground and in space as testbeds in preparation for human exploratory missions and to develop a test plan for ground and space campaigns; (v) to develop a roadmap for a future European strategy towards human exploratory missions, including preparatory activities and terrestrial applications and benefits. This paper covers the part of the HUMEX study dealing with lunar missions. A lunar base at the south pole where long-time sunlight and potential water ice deposits could be assumed was selected as the Moon reference scenario. The impact on human health, performance and well being has

been investigated from the view point of the effects of microgravity (during space travel), reduced gravity (on the Moon) and abrupt gravity changes (during launch and landing), of the effects of cosmic radiation including solar particle events, of psychological issues as well as general health care. Countermeasures as well as necessary research using ground-based test beds and/or the International Space Station have been defined. Likewise advanced life support systems with a high degree of autonomy and regenerative capacity and synergy effects were considered where bioregenerative life support systems and biodiagnostic systems become essential. Finally, a European strategy leading to a potential European participation in future human exploratory missions has been recommended.
NLM
Adaptation; Aerospace Medicine; Closed Ecological Systems; Moon; Radiation Protection

20040087856
Spaceflight hardware for conducting plant growth experiments in space: the early years 1960-2000
Porterfield, D. M., Author; Neichitailo, G. S., Author; Mashinski, A. L., Author; Musgrave, M. E., Author; Advances in space research : the official journal of the Committee on Space Research (COSPAR); 2003; Volume 31, Issue 1, 183-93; In English; Copyright; Avail: Other Sources

The best strategy for supporting long-duration space missions is believed to be bioregenerative life support systems (BLSS). An integral part of a BLSS is a chamber supporting the growth of higher plants that would provide food, water, and atmosphere regeneration for the human crew. Such a chamber will have to be a complete plant growth system, capable of providing lighting, water, and nutrients to plants in microgravity. Other capabilities include temperature, humidity, and atmospheric gas composition controls. Many spaceflight experiments to date have utilized incomplete growth systems (typically having a hydration system but lacking lighting) to study tropic and metabolic changes in germinating seedlings and young plants. American, European, and Russian scientists have also developed a number of small complete plant growth systems for use in spaceflight research. Currently we are entering a new era of experimentation and hardware development as a result of long-term spaceflight opportunities available on the International Space Station. This is already impacting development of plant growth hardware. To take full advantage of these new opportunities and construct innovative systems, we must understand the results of past spaceflight experiments and the basic capabilities of the diverse plant growth systems that were used to conduct these experiments. The objective of this paper is to describe the most influential pieces of plant growth hardware that have been used for the purpose of conducting scientific experiments during the first 40 years of research.
NLM
Agriculture; Closed Ecological Systems; Life Support Systems; Plants (Botany); Space Flight; Vegetation Growth

20030006863
Novel Amine-Functional Membrane for Metabolic CO2 Removal from Spacesuit Breathing Loop
Tsai, Chung-Yi A.; Guray, Ipek; Tang, Xia; Nalette, Tim; Thibaud-Erkey, Catherine; Brinker, C. Jeffrey; Xomerita, George; AIP Conference Proceedings; January 28, 2003; ISSN 0094-243X; Volume 654, Issue no. 1, 861-868; In English; SPACE TECHNOLOGY and APPLICATIONS INT.FORUM-STAIF 2003: Conf.on Thermophysics in Microgravity; Commercial/ Civil Next Generation Space Transportation; Human Space Exploration, 2-5 February 2003, Albuquerque, New Mexico, USA
Contract(s)/Grant(s): NAG91324; Copyright

We developed a unique porous membrane material with amine-functional pore surfaces using surfactant templating techniques for CO2 removal from the breathing loop of spacesuits. We use evaporation during coating to induce the formation of surfactant micelles that self-organize into desirable pore structures. The membrane, with secondary amine functional groups inside the membrane pores, showed a dual-gas separation factor at 90[deg]C that was ten times higher than the ideal Knudsen separation factor. A CO2 flux of 4 GPU (IGPU (gas permeation unit) =10-6 cm3 (STP)/cm2-s-cmHg) was observed. When the temperature was reduced to 20[deg]C, the mixed-gas separation factor increased two fold, indicating enhanced CO2 surface diffusion via active amine adsorption sites at lower temperatures. An amine-functional membrane could offer a unique alternative to NASA’s current capability for regeneratively removing CO2 from spacesuit breathing loop.
Author (AIP)
Carbon Compounds; Carbon Dioxide Removal; Evaporation; Membranes; Nitrogen Compounds; Oxygen Compounds; Porous Materials; Space Suits; Spacecraft

20040096106

Space Life Sciences: closed artificial ecosystems and life support systems

Advances in space research : the official journal of the Committee on Space Research (COSPAR); 2003; Volume 31, Issue 7, 1627-847; In English; Copyright; Avail: Other Sources

No abstract available

Closed Ecological Systems; Ecosystems; Life Sciences; Life Support Systems; Weightlessness

20040096105

Aquatic modules for bioregenerative life support systems: developmental aspects based on the space flight results of the C.E.B.A.S. MIN-MODULE

Blum, V., Author; Advances in space research : the official journal of the Committee on Space Research (COSPAR); 2003; Volume 31, Issue 7, 1683-91; In English; Copyright; Avail: Other Sources

The Closed Equilibrated Biological Aquatic System (C.E.B.A.S.) is an artificial aquatic ecosystem which contains teleost fishes, water snails, ammonia oxidizing bacteria and edible non-gravitropic water plants. It serves as a model for aquatic food production modules which are not seriously affected by microgravity and other space conditions. Its space flight version, the so-called C.E.B.A.S. MINI-MODULE was already successfully tested in the STS-89 and STS-90 (NEUROLAB) missions. It will be flown a third time in space with the STS-107 mission in January 2003. All results obtained so far in space indicate that the basic concept of the system is more than suitable to drive forward its development. The C.E.B.A.S. MINI-MODULE is located within a middeck locker with limited space for additional components. These technical limitations allow only some modifications which lead to a maximum experiment time span of 120 days which is not long enough for scientifically essential multi-generation-experiments. The first necessary step is the development of ‘harvesting devices’ for the different organisms. In the limited space of the plant bioreactor a high biomass production leads to self-shadowing effects which results in an uncontrolled degradation and increased oxygen consumption by microorganisms which will endanger the fishes and snails. It was shown already that the latter reproduce excellently in space and that the reproductive functions of the fish species are not affected. Although the parent-offspring-cannibalism of the ovoviviparous fish species (Xiphophorus helleri) serves as a regulating factor in population dynamics an uncontrolled snail reproduction will also induce an increased oxygen consumption per se and a high ammonia concentration in the water. If harvesting locks can be handled by astronauts in, e. g., 4-week intervals their construction is not very difficult and basic technical solutions are already developed. The second problem is the feeding of the animals. Although C.E.B.A.S.-based aquaculture modules are designed to be closed food loop systems (edible herbivorous fish species and edible water plants) which are already verified on Earth this will not be possible in space without devices in which the animals are fed from a food storage. This has to be done at least once daily which would waste too much crew time when done by astronauts. So, the development of a reliable automated food dispenser has highest priority. Also in this case basic technical solutions are already elaborated. The paper gives a comprehensive overview of the proposed further C.E.B.A.S.-based development of longer-term duration aquatic food production modules. c2003 COSPAR. Published by Elsevier Science Ltd. All rights reserved.

NLM

Aquiculture; Closed Ecological Systems; Life Support Systems; Marine Biology; Modules; Organisms; Regeneration (Physiology); Weightlessness

20040093786

Development of a pilot system for converting sweet potato starch into glucose syrup

Silayo, Valerian C K., Author; Lu, John Y., Author; Aglan, Heshmat A., Author; Bovell-Benjamin, A. C., Principal Investigator; Habitation (Elmsford, N.Y.); 2003; ISSN 1542-9660; Volume 9, Issue 1-2, 9-15; In English

Contract(s)/Grant(s): NCC9-51; Copyright; Avail: Other Sources

Sweet potato has been chosen as one of NASA’s crops to support human beings in future space missions. One of the possible uses is to make syrup that can be used as a general sweetener. In this work a simple engineering system for converting sweet potato starch into glucose syrup was studied on a laboratory scale. The system comprises the following main units: a blender, continuous stirred tank reactor (CSTR), centrifugal and vacuum filters, deionization column and vacuum evaporator. The system was tested by carrying out conversion processes from fresh sweet potato roots. The roots were pealed, sliced, homogenized, heated and hydrolyzed by diastase of malt and Dextrozyme C (Novo Nordisk BioChem, North America, Inc.) enzymes in the CSTR. After hydrolysis the slurry was filtered, de-ionized and concentrated to get glucose syrup. The performance of the system was evaluated based on the quality of the conversion. The main factor was the level of reducing sugars except for the deionization where ash content and color were the main factors. Through careful control of the system units, good heating performance in the CSTR was obtained and the hydrolysis process attained sufficient conversion. The

filtration process that incorporated the centrifuge was faster than when it was by-passed to the vacuum filter but losses in sugars were higher. Deionization removed more than 90% of the ash and reduced pigmentation, with probable insignificant losses in sugars during the deionization process. Recovery levels when the centrifuge was used and when it was by-passed could reach about 65% and 78%, respectively. These correspond to reducing sugar concentration of 259 and 310 mg/ml in 150-ml syrups from 300 g of sweet potatoes in each process. However, from concentration trials, syrups with volumes of 100 and 70 ml with the respective dextrose equivalence of 281 and 213 mg/ml were obtained. The syrups obtained were brownish in color and the process that employed centrifugal filtration gave a product with color that resembled the original color of the sweet potatoes. Further work is required to improve the overall system performance.
NLM
Bioreactors; Food; Glucose; Plants (Botany); Potatoes; Starches

20030068131 NASA Marshall Space Flight Center, Huntsville, AL, USA
Sabatier Engineering Development Unit
Perry, Jay; Smith, Fred; Murdoch, Karen; [2003]; In English, 7-10 Jul. 2003, Vancouver, BC, Canada
Report No.(s): SAE-2003-02-2496; Copyright; Avail: CASI; A02, Hardcopy

To facilitate life support system loop closure on board the International Space Station (ISS), the Node 3 Oxygen Generation System (OGS) rack contains a functional scar to accommodate a carbon dioxide reduction assembly (CRA). As part of the effort to better understand and define the functional scar, significant risk mitigation activities have been performed. To address integration risks, a CRA Engineering Development Unit (EDU) has been developed that is functionally equivalent to a flight CRA and is suitable for integrating with ground based carbon dioxide removal and oxygen generation systems. The CRA EDU has been designed to be functionally equivalent to the Sabatier Reactor Subsystem (SRS) portion of the CRA. The design of the CRA EDU and testing results in a stand alone configuration with simulated OGA and CDRA interfaces are reported. Carbon dioxide flow control is a major area requiring development since the size of the CO2 accumulator may result in periods of CRA starvation. The capability of the CO2 flow control algorithm to effectively manage integrated CRA operations is discussed.
Author
Carbon Dioxide Removal; Life Support Systems; Product Development

20040013505 NASA Ames Research Center, Moffett Field, CA, USA
Closed-loop Life Support Systems
Fisher, John W.; [2003]; In English, 6 Jun. 2003, Cleveland, OH, USA
Contract(s)/Grant(s): 131-20-00; No Copyright; Avail: CASI; A01, Hardcopy

Contents include the following: 1. Advanced life support requirements document-high level: (a) high level requirements and standards, (b) advanced life support requirements documents-air, food, water. 2. Example technologies that satisfy requrements: air system-carbon dioxide removal. 3. Air-sabatter. 4. International Space Station water treatment subsystem.5. Direct osmotic concentrator. 6. Mass, volume and power estimates.
CASI
Carbon Dioxide Removal; Support Systems; Water Treatment; Feedback Control

20040013506 NASA Ames Research Center, Moffett Field, CA, USA
Design and Development of an air-cooled Temperature-Swing Adsorption Compressor for Carbon Dioxide
Mulloth, Lila M.; [2003]; In English, 4-7 Jan. 2004, Orlando, FL, USA
Contract(s)/Grant(s): 131-20-10-26; Copyright; Avail: Other Sources; Abstract Only

The air revitalization system of the International Space Station (ISS) operates in an open loop mode and relies on the resupply of oxygen and other consumables from earth for the life support of astronauts. A compressor is required for delivering the carbon dioxide from a removal assembly to a reduction unit to recover oxygen and thereby closing the air-loop. We have a developed a temperature-swing adsorption compressor (TSAC) for performing these tasks that is energy efficient, quiet, and has no wearing parts. This paper discusses the design features of a TSAC hardware that uses air as the cooling medium and has Space Station application.
Author
Design Analysis; Fabrication; Air Cooling; Compressors; Carbon Dioxide Removal

20030067859 NASA Glenn Research Center, Cleveland, OH, USA

2001: A Space Odyssey Revisited: The Feasibility of 24 Hour Commuter Flights to the Moon Using NTR Propulsion with LUNOX Afterburners

Borowski, Stanley; Dudzinski, Leonard A.; June 2003; In English, 6-9 Jul. 1997, Seattle, WA, USA

Contract(s)/Grant(s): WU 953-20-0C

Report No.(s): NASA/TM-1998-208830/REV2; E-11441/REV2; NAS 1.15:208830/REV2; AIAA Paper 97-2956-Rev-2; No Copyright; Avail: CASI; A03, Hardcopy

The prospects for 24 hour commuter flights to the Moon, similar to that portrayed in 2001: A Space Odyssey but on a more Spartan scale, are examined using two near term, high leverage technologies: liquid oxygen (LOX)-augmented nuclear thermal rocket (NTR) propulsion and lunar-derived oxygen (LUNOX) production. Iron-rich volcanic glass, or orange soil, discovered during the Apollo 17 mission to Taurus-Littrow, has produced a 4 percent oxygen yield in recent NASA experiments using hydrogen reduction. LUNOX development and utilization would eliminate the need to transport oxygen supplies from Earth and is expected to dramatically reduce the size, cost and complexity of space transportation systems. The LOX-augmented NTR concept (LANTR) exploits the high performance capability of the conventional liquid hydrogen (LH2)-cooled NTR and the mission leverage provided by LUNOX in a unique way. LANTR utilizes the large divergent section of its nozzle as an afterburner into which oxygen is injected and supersonically combusted with nuclear preheated hydrogen emerging from the engine's choked sonic throat, essentially scramjet propulsion in reverse. By varying the oxygen-to-hydrogen mixture ratio, the LANTR engine can operate over a wide range of thrust and specific impulse (Isp) values while the reactor core power level remains relatively constant. The thrust augmentation feature of LANTR means that big engine performance can be obtained using smaller, more affordable, easier to test NTR engines. The use of high-density LOX in place of low density LH2 also reduces hydrogen mass and tank volume resulting in smaller space vehicles. An implementation strategy and evolutionary lunar mission architecture is outlined which requires only Shuttle C or in-line Shuttle-derived launch vehicles, and utilizes conventional NTR-powered lunar transfer vehicles (LTVs), operating in an expendable mode initially, to maximize delivered surface payload on each mission. The increased payload is dedicated to installing modular LUNOX production units with the intent of supplying LUNOX to lunar landing vehicles (LLVs) and then LTVs at the earliest possible opportunity. Once LUNOX becomes available in low lunar orbit (LLO), monopropellant NTRs would be outfitted with an oxygen propellant module, feed system and afterburner nozzle for bipropellant operation. Transition to a reusable mission architecture now occurs with smaller, LANTR-powered LTVs delivering ~400% more payload on each piloted round trip mission than earlier expendable all LH2 NTR systems. As initial lunar outposts grow to eventual lunar settlements and LUNOX production capacity increases, the LANTR concept can enable a rapid commuter shuttle capable of 24 hour one way trips to and from the Moon. A vast deposit of iron-rich volcanic glass beads identified at just one candidate site located at the southeastern edge of Mare Serenitatis could supply sufficient LUNOX to support daily commuter flights to the Moon for the next 9000 years!

Author

Space Transportation System; Shuttle Derived Vehicles; Liquid Rocket Propellants; Hydrogen Engines; Manned Space Flight; Lunar Landing

20040014954, NASA Ames Research Center, Moffett Field, CA, USA

Development of a Next-Generation Membrane-Integrated Adsorption Processor for CO2 Removal and Compression for Closed-Loop Air Revitalization Systems

Mulloth, Lila; LeVan, Douglas; [2002]; In English, 7-10 Jul. 2003, Vancouver, British Columbia, Canada

Contract(s)/Grant(s): NAS2-14263; No Copyright; Avail: Other Sources; Abstract Only

The current CO_2 removal technology of NASA is very energy intensive and contains many non-optimized subsystems. This paper discusses the concept of a next-generation, membrane integrated, adsorption processor for CO_2 removal nd compression in closed-loop air revitalization systems. This processor will use many times less power than NASA's current CO_2 removal technology and will be capable of maintaining a lower CO_2 concentration in the cabin than that can be achieved by the existing CO_2 removal systems. The compact, consolidated, configuration of gas dryer, CO_2 separator, and CO_2 compressor will allow continuous recycling of humid air in the cabin and supply of compressed CO_2 to the reduction unit for oxygen recovery. The device has potential application to the International Space Station and future, long duration, transit, and planetary missions.

Author

Carbon Dioxide Removal; Recycling; Oxygen; Feedback Control; Compressors; Carbon Dioxide Concentration

20040087583

Modelling the effect of diffuse light on canopy photosynthesis in controlled environments

Cavazzoni, James, Author; Volk, Tyler, Author; Tubiello, Francesco, Author; Monje, Oscar, Author; Janes, H. W., Principal Investigator; Acta horticulturae; 2002; ISSN 0567-7572; Volume 593, 39-45; In English

Contract(s)/Grant(s): NAGW-5003; Copyright; Avail: Other Sources

A layered canopy model was used to analyze the effects of diffuse light on canopy gross photosynthesis in controlled environment plant growth chambers, where, in contrast to the field, highly diffuse light can occur at high irradiance. The model suggests that high diffuse light fractions (approximately 0.7) and irradiance (1400 micromoles m-2 s-1) may enhance crop life-cycle canopy gross photosynthesis for hydroponic wheat by about 20% compared to direct light at the same irradiance. Our simulations suggest that high accuracy is not needed in specifying diffuse light fractions in chambers between approximately 0.7 and 1, because simulated photosynthesis for closed canopies plateau in this range. We also examined the effect of leaf angle distribution on canopy photosynthesis under growth chamber conditions, as these distributions determine canopy extinction coefficients for direct and diffuse light. We show that the spherical leaf angle distribution is not suitable for modeling photosynthesis of planophile canopies (e.g., soybean and peanut) in growth chambers. Also, the absorption of the light reflected from the surface below the canopy should generally be included in model simulations, as the corresponding albedo values in the photosynthetically active range may be quite high in growth chambers (e.g., approximately 0.5). In addition to the modeling implications, our results suggest that diffuse light conditions should be considered when drawing conclusions from experiments in controlled environments.

NLM

Computerized Simulation; Controlled Atmospheres; Environmental Control; Light (Visible Radiation); Models; Photosynthesis; Plant Physiology; Plants (Botany)

20040087939

Enzyme-based CO2 capture for advanced life support

Ge, Jijun, Author; Cowan, Robert M., Author; Tu, Chingkuang, Author; McGregor, Martin L., Author; Trachtenberg, Michael C., Author; Life support & biosphere science : international journal of earth space; 2002; ISSN 1069-9422; Volume 8, Issue 3-4, 181-9; In English

Contract(s)/Grant(s): NAG9-1923; Copyright; Avail: Other Sources

Elevated CO2 levels in air can lead to impaired functioning and even death to humans. Control of CO2 is critical in confined spaces that have little physical or biological buffering capacity (e.g., spacecraft, submarines, or aircraft). A novel enzyme-based contained liquid membrane bioreactor was designed for CO2 capture and certain application cases are reported in this article. The results show that the liquid layer accounts for the major transport resistance. With addition of carbonic anhydrase, the transport resistance decreased by 71%. Volatile organic compounds of the type and concentration expected to be present in either the crew cabin or a plant growth chamber did not influence carbonic anhydrase activity or reactor operation during 1-day operation. Alternative sweep method studies, examined as a means of eliminating consumables, showed that the feed gas could be used successfully in a bypass mode when combined with medium vacuum pressure (-85 kPa) to achieve CO2 separation comparable to that with an inert sweep gas. The reactor exhibited a selectivity for CO2 versus N2 of 1400:1 and CO2 versus O2 is 866:1. The CO2 permeance was 1.44 x 10(-7) mol m-2 Pa-1 s-1 (4.3 x 10(-4) cm3 cm-2 s-1 cmHg-1) at a feed concentration of 0.1% CO2. These data show that the enzyme-based contained liquid membrane is a promising candidate technology that may be suitable for NASA applications to control CO2 in the crew or plant chambers.

NLM

Bioreactors; Carbon Dioxide; Carbonic Anhydrase; Closed Ecological Systems; Enzymes; Life Support Systems

20040087941

Light, plants, and power for life support on Mars

Salisbury, F. B., Author; Dempster, W. F., Author; Allen, J. P., Author; Alling, A., Author; Bubenheim, D., Author; Nelson, M., Author; Silverstone, S., Author; Life support & biosphere science : international journal of earth space; 2002; ISSN 1069-9422; Volume 8, Issue 3-4, 161-72; In English; Copyright; Avail: Other Sources

Regardless of how well other growing conditions are optimized, crop yields will be limited by the available light up to saturation irradiances. Considering the various factors of clouds on Earth, dust storms on Mars, thickness of atmosphere, and relative orbits, there is roughly 2/3 as much light averaged annually on Mars as on Earth. On Mars, however, crops must be grown under controlled conditions (greenhouse or growth rooms). Because there presently exists no material that can safely be pressurized, insulated, and resist hazards of puncture and deterioration to create life support systems on Mars while allowing for sufficient natural light penetration as well, artificial light will have to be supplied. If high irradiance is provided

for long daily photoperiods, the growing area can be reduced by a factor of 3-4 relative to the most efficient irradiance for cereal crops such as wheat and rice, and perhaps for some other crops. Only a small penalty in required energy will be incurred by such optimization. To obtain maximum yields, crops must be chosen that can utilize high irradiances. Factors that increase ability to convert high light into increased productivity include canopy architecture, high-yield index (harvest index), and long-day or day-neutral flowering and tuberization responses. Prototype life support systems such as Bios-3 in Siberia or the Mars on Earth Project need to be undertaken to test and further refine systems and parameters.
NLM
Closed Ecological Systems; Life Support Systems; Light (Visible Radiation); Mars (Planet); Plants (Botany)

20040087940
Swiss chard: a salad crop for the space program
Logendra, Logan S., Author; Gilrain, Matthew R., Author; Gianfagna, Thomas J., Author; Janes, Harry W., Author; Life support & biosphere science : international journal of earth space; 2002; ISSN 1069-9422; Volume 8, Issue 3-4, 173-9; In English; Copyright; Avail: Other Sources

Salad greens will be among the first crops grown on lunar or planetary space stations. Swiss chard (Beta vulgaris L.) is an important candidate salad crop because it is high yielding and rich in vitamins and minerals. Five Swiss chard cultivars were grown in the greenhouse under two light levels for 13 weeks to compare cumulative yields from weekly harvests, mineral composition, and to evaluate sensory attributes as a salad green. The varieties Large White Ribbed (LWR) and Lucullus (LUC) were the highest yielding in both light regimes. LWR was the shortest of the cultivars requiring the least vertical space. LWR also received the highest sensory ratings of the five cultivars. LWR Swiss chard should be considered as an initial test variety in food production modules.
NLM
Closed Ecological Systems; Eating; Farm Crops; Light (Visible Radiation); Plants (Botany); Space Programs

20040103892
Life support for aquatic species--past; present; future
Slenzka, K., Author; Advances in space research : the official journal of the Committee on Space Research (COSPAR); 2002; Volume 30, Issue 4, 789-95; In English; Copyright; Avail: Other Sources

Life Support is a basic issue since manned space flight began. Not only to support astronauts and cosmonauts with the essential things to live, however, also animals which were carried for research to space etc. together with men need support systems to survive under space conditions. Most of the animals transported to space participate at the life support system of the spacecraft. However, aquatic species live in water as environment and thus need special developments. Research with aquatic animals has a long tradition in manned space flight resulting in numerous life support systems for them starting with simple plastic bags up to complex support hardware. Most of the recent developments have to be identified as part of a technological oriented system and can be described as small technospheres. As the importance arose to study our Earth as the extraordinary Biosphere we live in, the modeling of small ecosystems began as part of ecophysiological research. In parallel the investigations of Bioregenerative Life Support Systems were launched and identified as necessity for long-term space missions or traveling to Moon and Mars and beyond. This paper focus on previous developments of Life Support Systems for aquatic animals and will show future potential developments towards Bioregenerative Life Support which additionally strongly benefits to our Earth's basic understanding. c2002 COSPAR. Published by Elsevier Science Ltd. All rights reserved.
NLM
Aquiculture; Closed Ecological Systems; Life Support Systems; Weightlessness

20040087633
Evaluation of two fiber optic-based solar collection and distribution systems for advanced space life support
Jack, D. A., Author; Nakamura, T., Author; Sadler, P., Author; Cuello, J. L., Author; Transactions of the ASAE. American Society of Agricultural Engineers; Sep-Oct 2002; ISSN 0001-2351; Volume 45, Issue 5, 1547-58; In English
Contract(s)/Grant(s): NAS10-97056; NAG5-4456; Copyright; Avail: Other Sources

Growing plants in an enclosed controlled environment is crucial in developing bioregenerative life-support systems (BLSS) for space applications. The major challenge currently facing a BLSS is the extensive use of highly energy-intensive electric light sources, which leads to substantial energy wastes through heat dissipations by these lamps. An alternative lighting strategy is the use of a solar irradiance collection, transmission, and distribution system (SICTDS). Two types of fiber optic-based SICTDS, a Fresnel-lens Himawari and a parabolic-mirror optical waveguide (OW) lighting system, were

evaluated. The overall efficiency for the OW SICTDS of 40.5% exceeded by 75% that for the Himawari of 23.2%. The spectral distributions of the light delivered by the Himawari and the OW SICTDS were almost identical and had practically no difference from that of terrestrial solar radiation. The ratios of photosynthetically active radiation (PAR) to total emitted radiation (k) of 0.39 +/- 0.02 for the Himawari and 0.41 +/- 0.04 for the OW SICTDS were statistically indistinguishable, were not significantly different from that of 0.042 +/- 0.01 for terrestrial solar radiation, and were comparable to that of 0.35 for a high-pressure sodium (HPS) lamp. The coefficients of variation (CV) of 0.34 and 0.39 for PPF distributions, both at 50 mm X 50 mm square grid arrays, corresponding to the Himawari and the OW SICTDS, respectively, were comparable with each other but were both significantly greater than the CV of 0.08 corresponding to the HPS lamp. The average fresh weight or dry weight of lettuce grown in the solar chamber with either the Himawari or the OW SICTDS showed no statistical difference from the average fresh weight or dry weight of lettuce grown in the reference chamber with the HPS lamp. The results of this study suggest that an SICTDS could help reduce the electric power demand in a BLSS.
NLM

Closed Ecological Systems; Fiber Optics; Life Support Systems; Solar Energy; Sunlight; Vegetables

20040087624

Characterization of iron, manganese, and copper synthetic hydroxyapatites by electron paramagnetic resonance spectroscopy

Sutter, B., Author; Wasowicz, T., Author; Howard, T., Author; Hossner, L. R., Author; Ming, D. W., Author; Soil Science Society of America journal. Soil Science Society of America; Jul-Aug 2002; ISSN 0361-5995; Volume 66, Issue 4, 1359-66; In English

Contract(s)/Grant(s): NGT5-1229; Copyright; Avail: Other Sources

The incorporation of micronutrients (e.g., Fe, Mn, Cu) into synthetic hydroxyapatite (SHA) is proposed for slow release of these nutrients to crops in NASA's Advanced Life Support (ALS) program for long-duration space missions. Separate Fe3+ (Fe-SHA), Mn2+ (Mn-SHA), and Cu2+ (Cu-SHA) containing SHA materials were synthesized by a precipitation method. Electron paramagnetic resonance (EPR) spectroscopy was used to determine the location of Fe3+, Mn2+, and Cu2+ ions in the SHA structure and to identify other Fe(3+)-, Mn(2+)-, and Cu(2+)-containing phases that formed during precipitation. The EPR parameters for Fe3+ (g=4.20 and 8.93) and for Mn2+ (g=2.01, A=9.4 mT, D=39.0 mT and E=10.5 mT) indicated that Fe3+ and Mn2+ possessed rhombic ion crystal fields within the SHA structure. The Cu2+ EPR parameters (g(z)=2.488, A(z)=5.2 mT) indicated that Cu2+ was coordinated to more than six oxygens. The rhombic environments of Fe3+ and Mn2+ along with the unique Cu2+ environment suggested that these metals substituted for the 7 or 9 coordinate Ca2+ in SHA. The EPR analyses also detected poorly crystalline metal oxyhydroxides or metal-phosphates associated with SHA. The Fe-, Mn-, and Cu-SHA materials are potential slow release sources of Fe, Mn, and Cu for ALS and terrestrial cropping systems.
NLM

Calcium Phosphates; Copper; Electron Paramagnetic Resonance; Fertilizers; Iron; Life Support Systems; Manganese; Minerals; Spectroscopy

20040113750

Special issue from the workshop 'Ecosynthesis: Creating Open and Closed Ecosystems on Mars'

Life support & biosphere science : international journal of earth space; 2002; ISSN 1069-9422; Volume 8, Issue 2, 65-123; In English; Copyright; Avail: Other Sources

No abstract available

Closed Ecological Systems; Ecosystems; Life Support Systems; Mars (Planet); Plants (Botany)

20040113748

Human factor observations of the Biosphere 2, 1991-1993, closed life support human experiment and its application to a long-term manned mission to Mars

Alling, Abigail, Author; Nelson, Mark, Author; Silverstone, Sally, Author; Van Thillo, Mark, Author; Life support & biosphere science : international journal of earth space; 2002; ISSN 1069-9422; Volume 8, Issue 2, 71-82; In English; Copyright; Avail: Other Sources

Human factors are a key component to the success of long-term space missions such as those necessitated by the human exploration of Mars and the development of bioregenerative and eventually self-sufficient life support systems for permanent space outposts. Observations by participants living inside the 1991-1993 Biosphere 2 closed system experiment provide the following insights. (1) Crew members should be involved in the design and construction of their life support systems to gain

maximum knowledge about the systems. (2) Individuals living in closed life support systems should expect a process of physiological and psychological adaptation to their new environment. (3) Far from simply being a workplace, the participants in such extended missions will discover the importance of creating a cohesive and satisfying life style. (4) The crew will be dependent on the use of varied crops to create satisfying cuisine, a social life with sufficient outlets of expression such as art and music, and to have down-time from purely task-driven work. (5) The success of the Biosphere 2 first 2-year mission suggests that crews with high cultural diversity, high commitment to task, and work democracy principles for individual responsibility may increase the probability of both mission success and personal satisfaction. (6) Remaining challenges are many, including the need for far more comprehensive real-time modeling and information systems (a 'cybersphere') operating to provide real-time data necessary for decision-making in a complex life support system. (7) And, the aim will be to create a noosphere, or sphere of intelligence, where the people and their living systems are in sustainable balance.
NLM
Adaptation; Biosphere; Closed Ecological Systems; Group Dynamics; Life Support Systems; Manned Mars Missions; Mars (Planet); Mars Missions; Space Environment Simulation

20040102920
Adaptive environmental control for optimal results during plant microgravity experiments
Kostov, P., Author; Ivanova, T., Author; Dandolov, I., Author; Sapunova, S., Author; Ilieva, I., Author; Acta astronautica; Jul-Nov 2002; ISSN 0094-5765; Volume 51, Issue 1-9, 213-20; In English; Copyright; Avail: Other Sources

The SVET Space Greenhouse (SG)--the first and the only automated plant growth facility onboard the MIR Space Station in the period 1990-2000 was developed on a Russian-Bulgarian Project in the 80s. The aim was to study plant growth under microgravity in order to include plants as a link of future Biological Life Support Systems for the long-term manned space missions. An American developed Gas Exchange Measurement System (GEMS) was added to the existing SVET SG equipment in 1995 to monitor more environmental and physiological parameters. A lot of long-duration plant flight experiments were carried out in the SVET+GEMS. They led to significant results in the Fundamental Gravitational Biology field--second-generation wheat seeds were produced in the conditions of microgravity. The new International Space Station (ISS) will provide a perfect opportunity for conducting full life cycle plant experiments in microgravity, including measurement of more vital plant parameters, during the next 15-20 years. Nowadays plant growth facilities for scientific research based on the SVET SG functional principles are developed for the ISS by different countries (Russia, USA, Italy, Japan, etc.). A new Concept for an advanced SVET-3 Space Greenhouse for the ISS, based on the Bulgarian experience and 'know-how' is described. The absolute and differential plant chamber air parameters and some plant physiological parameters are measured and processed in real time. Using the transpiration and photosynthesis measurement data the Control Unit evaluates the plant status and performs adaptive environmental control in order to provide the most favorable conditions for plant growth at every stage of plant development in experiments. A conceptual block-diagram of the SVET-3 SG is presented. c2002 International Astronautical Federation. Published by Elsevier Science Ltd. All rights reserved.
NLM
Adaptive Control; Closed Ecological Systems; Environmental Control; Gravitational Effects; Life Support Systems; Microgravity; Plants (Botany); Weightlessness

20030018412 Institute of Space Medico-Engineering, Beijing, China
Overall Design and Proof-Test of an Integrated Environmental Control and Life Support System (ECLSS) for Demonstration and Verification
Rui, Jia-Bai; Zheng, Chuan-Xian; Zeng, Qing-Tang; Space Medicine and Medical Engineering; December 2002; ISSN 1002-0837; Volume 15, Issue No. 6, 423-427; In Chinese; Copyright; Avail: Other Sources

To test and demonstrate embryonic form of our future space station ECLSS, which will also form an advanced research and test ground facility. The following functions of the system were tested and demonstrated: integrated solid amine CO, collection and concentration, Sabatier CO, reduction,urine processing thermoelectric integrated membrane evaporation, solid polymer water electrolysis O2 generation, concentrated ventilation, temperature and humidity control, the measurement and control system, and other non-regenerative techniques. All of these were demonstrated in a sealed adiabatic module, and passed the proof-tests. The principal technical requirements of the system and each regenerative subsystem were met. The integration of system general and each subsystem was successful, and the partial closed loop of the system's integration has been realized basically. The reasonableness of the project design was verified, and the major system technical requirements were satisfied. The suitability and harmonization among system general and each subsystem were good, the system operated normally, and the parameters measured were correct.
Author
Space Stations; Life Support Systems; Environmental Control; Systems Integration; Design Analysis; Spacecraft Equipment

20040110157

Tolerance of LSS plant component to elevated temperatures

Ushakova, S. A., Author; Tikhomirov, A. A., Author; Acta astronautica; Jun 2002; ISSN 0094-5765; Volume 50, Issue 12, 759-64; In English; Copyright; Avail: Other Sources

Stability of LSS based on biological regeneration of water, air and food subject to damaging factors is largely dependent on the behavior of the photosynthesizing component represented, mainly, by higher plants. The purpose of this study is to evaluate the tolerance of uneven-aged wheat and radish cenoses to temperature effects different in time and value. Estimation of thermal tolerance of plants demonstrated that exposure for 20 h to the temperature increasing to 45 degrees C brought about irreversible damage both in photosynthetic processes (up to 80% of initial value) and the processes of growth and development. Kinetics of visible photosynthesis during exposure to elevated temperatures can be used to evaluate critical exposure time within the range of which the damage of metabolic processes is reversible. With varying light intensity and air temperature it is possible to find a time period admissible for the plants to stay under adverse conditions without considerable damage of metabolic processes. c2002 Elsevier Science Ltd. All rights reserved.

NLM

Closed Ecological Systems; Heat; High Temperature; Life Support Systems; Photosynthesis; Plants (Botany); Wheat

20040110155

Novel aquatic modules for bioregenerative life-support systems based on the closed equilibrated biological aquatic system (C.E.B.A.S.)

Bluem, Volker, Author; Paris, Frank, Author; Acta astronautica; Jun 2002; ISSN 0094-5765; Volume 50, Issue 12, 775-85; In English; Copyright; Avail: Other Sources

The closed equilibrated biological aquatic system (C.E.B.A.S) is a man-made aquatic ecosystem which consists of four subcomponents: an aquatic animal habitat, an aquatic plant bioreactor, an ammonia oxidizing bacteria filter and a data acquisition/control unit. It is a precursor for different types of fish and aquatic plant production sites which are disposed for the integration into bioregenerative life-support systems. The results of two successful spaceflights of a miniaturized C.E.B.A.S version (the C.E.B.A.S. MINI MODULE) allow the optimization of aquatic food production systems which are already developed in the ground laboratory and open new aspects for their utilization as aquatic modules in space bioregenerative life support systems. The total disposition offers different stages of complexity of such aquatic modules starting with simple but efficient aquatic plant cultivators which can be implemented into water recycling systems and ending up in combined plant/fish aquaculture in connection with reproduction modules and hydroponics applications for higher land plants. In principle, aquaculture of fishes and/or other aquatic animals edible for humans offers optimal animal protein production under lowered gravity conditions without the tremendous waste management problems connected with tetrapod breeding and maintenance. The paper presents details of conducted experimental work and of future dispositions which demonstrate clearly that aquaculture is an additional possibility to combine efficient and simple food production in space with water recycling utilizing safe and performable biotechnologies. Moreover, it explains how these systems may contribute to more variable diets to fulfill the needs of multicultural crews. c2002 Elsevier Science Ltd. All rights reserved.

NLM

Aquiculture; Closed Ecological Systems; Life Support Systems; Modules; Regeneration (Physiology); Weightlessness

20040087937

Bioregenerative food system cost based on optimized menus for advanced life support

Waters, Geoffrey C R., Author; Olabi, Ammar, Author; Hunter, Jean B., Author; Dixon, Mike A., Author; Lasseur, Christophe, Author; Life support & biosphere science : international journal of earth space; 2002; ISSN 1069-9422; Volume 8, Issue 3-4, 199-210; In English; Copyright; Avail: Other Sources

Optimized menus for a bioregenerative life support system have been developed based on measures of crop productivity, food item acceptability, menu diversity, and nutritional requirements of crew. Crop-specific biomass requirements were calculated from menu recipe demands while accounting for food processing and preparation losses. Under the assumption of staggered planting, the optimized menu demanded a total crop production area of 453 m2 for six crew. Cost of the bioregenerative food system is estimated at 439 kg per menu cycle or 7.3 kg ESM crew-1 day-1, including agricultural waste processing costs. On average, about 60% (263.6 kg ESM) of the food system cost is tied up in equipment, 26% (114.2 kg ESM) in labor, and 14% (61.5 kg ESM) in power and cooling. This number is high compared to the STS and ISS (nonregenerative) systems but reductions in ESM may be achieved through intensive crop productivity improvements,

reductions in equipment masses associated with crop production, and planning of production, processing, and preparation to minimize the requirement for crew labor.
NLM
Closed Ecological Systems; Costs; Diets; Food; Life Support Systems; Plants (Botany); Regeneration (Physiology)

20030005546 Battelle Memorial Inst., Richland, WA USA
Microchannel Phase Separation and Partial Condensation in Normal and Reduced Gravity Environments
TeGrotenhuis, Ward E.; Stenkamp, Victoria S.; Sixth Microgravity Fluid Physics and Transport Phenomena Conference: Exposition Topical Areas 1-6; November 2002; Volume 2, 122-123; In English; Original contains color illustrations; No Copyright; Avail: CASI; A01, Hardcopy

Microtechnology was conceived as a means of shrinking the length scales of heat and mass transfer to 100 microns or less so that orders of magnitude increases in throughput can be realized in chemical processes. The subsequent reduction in size and mass lends itself well to space applications. Using proprietary sheet architecture, Battelle has created such devices with micro chemical and thermal systems (MicroCATS) for gas phase reactions, heat transfer and solvent extraction. In this work, Battelle has extended the technology to include phase separation and partial condensation with phase separation in channels between 100 microns and a few millimeters at the smallest dimension. These length scale channels are advantageous for all reduced gravity applications involving two-phase flow since hydrodynamic, interfacial and capillary forces dominate over gravitational forces. By controlling the wettability and porosity of the materials within the device, separation occurs spontaneously thus allowing high throughputs and easy recovery from process upsets. Enhanced heat transfer in the case of condensation is obtained through reduction of the narrowest channel dimension. Scale up is achieved by simply increasing the number of layers. Potential space applications for phase separation and condensation include water management in environmental control and life support and thermal systems involving phase change (heat pipes, vapor compression cycles). These devices are also well suited for in-situ resource utilization or ‘living off the land’ since they are compact and efficient. Applications include phase separation and condensation of water during in-situ propellant production.
Author
Two Phase Flow; Microgravity; Phase Separation (Materials); Phase Transformations; Nanotechnology; Condensing; Fluid Dynamics

20030003666 Florida Univ., FL USA
The Use of Pulsatile Flow to Separate Species
Narayanan, R.; Thomas, Aaron M.; Sixth Microgravity Fluid Physics and Transport Phenomena Conference; November 2002; Volume 1, 938-963; In English; No Copyright; Avail: CASI; A03, Hardcopy

The removal of carbon dioxide from air is important in producing a habitable environment for the self-supporting space stations of the space program. Pulsatile flow is a novel way to help in the partial separation of different species from air by using a purely mechanical method. The advantage of this is that no chemicals are needed. Pulsatile flow also has the advantage that it can handle large volumes. While it is not expected that this process will replace existing methods of separation, it can surely be used as a means to assist in the overall separation process, possibly as a precursor to conventional methods. This work specifically focuses on the physics of pulsatile flow and its effect on the mass transfer of species and the separation that can be achieved. From the theoretical model that predicts the mass transfer and separation of species, we provide a physical explanation of the phenomena predicted by the models. If two dilute species are present in a carrier, the mass transfer of the faster diffusing species may be higher, lower, or the same as the slow diffusing species. This depends on the time constants associated with the system and the ability of a species to remain in the fast moving portion of the flow field. The difference in the mass transfer of each species can lead to a separation that can be used in a number of processes including the removal of carbon dioxide from the air. This phenomenon is modeled in an open tube geometry and in the annular space between two concentric cylinders. Further, in annular pulsatile flow, the effect of the inner cylinder being off center from the outer cylinder on the mass transfer and separation is also analyzed. Experiments were also conducted to verify the validity of the models and the viability of pulsatile flows as a separations procedure.
Author
Gas-Gas Interactions; Carbon Dioxide; Carbon Dioxide Removal; Flow Distribution; Gas Flow; Gas Dynamics; Gaseous Diffusion

20040106409

MELISSA: a loop of interconnected bioreactors to develop life support in space

Godia, F., Author; Albiol, J., Author; Montesinos, J. L., Author; Perez, J., Author; Creus, N., Author; Cabello, F., Author; Mengual, X., Author; Montras, A., Author; Lasseur, Ch, Author; Journal of biotechnology; Nov 13 2002; ISSN 0168-1656; Volume 99, Issue 3, 319-30; In English; Copyright; Avail: Other Sources

The development of a loop of interconnected continuous bioreactors, aimed to provide life support in space, is reported. The complete loop concept consists of four bioreactors and one higher plant compartment. For its realization the continuous and controlled operation of the bioreactors is characterized, up to the pilot scale level, first for each individual reactor, second for the interconnected reactor operation. The results obtained with the two more advanced bioreactors in the Micro Ecological Life Support System Alternative (MELISSA) loop are described more specifically. These reactors consist of a packed-bed reactor working with an immobilized co-culture of Nitrosomonas and Nitrobacter cells, and an external loop gas-lift photobioreactor for the culture of the cyanobacteria Spirulina platensis. Their individual operation for long duration runs has been achieved and characterized, and their interconnected operation at pilot scale is reported.

NLM

Bioreactors; Closed Ecological Systems; Culture Techniques; Earth Resources; Ecosystems; Life Support Systems

20030000981 NASA Marshall Space Flight Center, Huntsville, AL USA

Air Purification in Closed Environments: An Overview of Spacecraft Systems

Perry, Jay L.; LeVan, Douglas; Crumbley, Robert, Technical Monitor; [2002]; In English; Nuclear Biological Chemical Defense Collective Protection Conference, 29-31 Oct. 2002, Orlando, FL, USA; No Copyright; Avail: Other Sources; Abstract Only

The primary goal for a collective protection system and a spacecraft environmental control and life support system (ECLSS) are strikingly similar. Essentially both function to provide the occupants of a building or vehicle with a safe, habitable environment. The collective protection system shields military and civilian personnel from short-term exposure to external threats presented by toxic agents and industrial chemicals while an ECLSS sustains astronauts for extended periods within the hostile environment of space. Both have air quality control similarities with various aircraft and 'tight' buildings. This paper reviews basic similarities between air purification system requirements for collective protection and an ECLSS that define surprisingly common technological challenges and solutions. Systems developed for air revitalization on board spacecraft are discussed along with some history on their early development as well as a view of future needs. Emphasis is placed upon two systems implemented by the National Aeronautics and Space Administration (NASA) onboard the International Space Station (ISS): the trace contaminant control system (TCCS) and the molecular sieve-based carbon dioxide removal assembly (CDRA). Over its history, the NASA has developed and implemented many life support systems for astronauts. As the duration, complexity, and crew size of manned missions increased from minutes or hours for a single astronaut during Project Mercury to days and ultimately months for crews of 3 or more during the Apollo, Skylab, Shuttle, and ISS programs, these systems have become more sophisticated. Systems aboard spacecraft such as the ISS have been designed to provide long-term environmental control and life support. Challenges facing the NASA's efforts include minimizing mass, volume, and power for such systems, while maximizing their safety, reliability, and performance. This paper will highlight similarities and differences among air purification systems. Additional information is included in the original extended abstract.

Author

Manned Space Flight; Life Support Systems; Air Purification; Environmental Control; Carbon Dioxide Removal; Trace Contaminants

20040104649

Potential integration of wetland wastewater treatment with space life support systems

Nelson, M., Author; Alling, A., Author; Dempster, W. F., Author; Van Thillo, M., Author; Allen, J. P., Author; Life support & biosphere science : international journal of earth space; 2002; ISSN 1069-9422; Volume 8, Issue 3-4, 149-54; In English; Copyright; Avail: Other Sources

Subsurface-flow constructed wetlands for wastewater treatment and nutrient recycling have a number of advantages in planetary exploration scenarios: they are odorless, relatively low labor and low energy, assist in purification of water and recycling of atmospheric CO2, and can directly grow some food crops. This article presents calculations for integration of wetland wastewater treatment with a prototype ground-based experimental facility ('Mars on Earth') supporting four people showing that an area of 4-6 m2 may be sufficient to accomplish wastewater treatment and recycling. Discharge water from the wetland system can be used as irrigation water for the agricultural crop area, thus ensuring complete reclamation and

utilization of nutrients within the bioregenerative life support system. Because the primary requirements for wetland treatment systems are warm temperatures and lighting, such bioregenerative systems can be integrated into space life support systems because heat from the lights may be used for temperature maintenance in the human living environment. Subsurface-flow wetlands can be modified for space habitats to lower space and mass requirements. Many of its construction requirements can eventually be met with use of in situ materials, such as gravel from the Mars surface. Because the technology does not depend on machinery and chemicals, and relies more on natural ecological mechanisms (microbial and plant metabolism), maintenance requirements (e.g., pumps, aerators, and chemicals) are minimized, and systems may have long operating lifetimes. Research needs include suitability of Martian soil and gravel for wetland systems, system sealing and liner options in a Mars base, and determination of wetland water quality efficiency under varying temperature and light regimes.
NLM
Aerospace Systems; Closed Ecological Systems; Life Support Systems; Liquid Wastes; Waste Disposal; Waste Water

20040104648

Airtight sealing a Mars base

Dempster, William F., Author; Life support & biosphere science : international journal of earth space; 2002; ISSN 1069-9422; Volume 8, Issue 3-4, 155-60; In English; Copyright; Avail: Other Sources

Atmospheric leakage from a Mars base would create a demand for continuous or periodic replenishment, which would in turn require extraction or mining for oxygen and other gases from local resources and attendant equipment and energy requirements for such operations. It therefore becomes a high priority to minimize leakage. This article quantifies leak rates as determined by the size of holes and discusses the implications of pressure for structural configuration. The author engineered the sealing of Biosphere 2 from which comparisons are drawn.
NLM
Architecture; Atmospheric Pressure; Closed Ecological Systems; Life Support Systems; Mars (Planet); Sealing

20040104303

Special section from the workshop 'Ecosynthesis: creating open and closed ecosystems on Mars'

Life support & biosphere science : international journal of earth space; 2002; ISSN 1069-9422; Volume 8, Issue 3-4, 125-72; In English; Copyright; Avail: Other Sources

No abstract available
Closed Ecological Systems; Ecosystems; Life Support Systems; Mars (Planet); Weightlessness

20040088378

Plants in space

Ferl, Robert, Author; Wheeler, Raymond, Author; Levine, Howard G., Author; Paul, Anna Lisa, Author; Current opinion in plant biology; Jun 2002; ISSN 1369-5266; Volume 5, Issue 3, 258-63; In English; Copyright; Avail: Other Sources

Virtually all scenarios for the long-term habitation of spacecraft and other extraterrestrial structures involve plants as important parts of the contained environment that would support humans. Recent experiments have identified several effects of spaceflight on plants that will need to be more fully understood before plant-based life support can become a reality. The International Space Station (ISS) is the focus for the newest phase of space-based research, which should solve some of the mysteries of how spaceflight affects plant growth. Research carried out on the ISS and in the proposed terrestrial facility for Advanced Life Support testing will bring the requirements for establishing extraterrestrial plant-based life support systems into clearer focus.
NLM
Closed Ecological Systems; Extraterrestrial Environments; Plants (Botany)

20040088353

Toward Martian agriculture: responses of plants to hypobaria

Corey, Kenneth A., Author; Barta, Daniel J., Author; Wheeler, Raymond M., Author; Life support & biosphere science : international journal of earth space; 2002; ISSN 1069-9422; Volume 8, Issue 2, 103-14; In English; Copyright; Avail: Other Sources

The recent surge of interest in human missions to Mars has also generated considerable interest in the responses of plants to hypobaria (reduced atmospheric pressure), particularly among those in the advanced life support community. Potential for in situ resource utilization, challenges in meeting engineering constraints for mass and energy, the prospect of using

lightweight plant growth structures on Mars, and the minimal literature on plant responses to low pressure all suggest much needed research in this area. However, the limited literature on hypobaria combined with previous findings on plant responses to atmospheric composition and established principles of mass transfer of gases suggest that some plants will be capable of tolerating and growing at pressures below 20 kPa; and for other species, perhaps as low as 5-10 kPa. In addition, normal and perhaps enhanced growth of many plants will likely occur at reduced partial pressures of oxygen (e.g., 5 kPa). Growth of plants at such low and partial pressures indicates the feasibility of cultivating plants in lightweight, transparent 'greenhouses' on the surface of Mars or in other extraterrestrial or extreme environment locations. There are numerous, accessible terrestrial analogs for moderately low pressure ranges, but not for very low and extremely low atmospheric pressures. Research pertaining to very low pressures has been historically restricted to the use of vacuum chambers. Future research prospects, approaches, and priorities for plant growth experiments at low pressure are considered and discussed as they apply to prospects for Martian agriculture.
NLM
Adaptation; Atmospheric Pressure; Closed Ecological Systems; Life Support Systems; Mars (Planet); Plants (Botany)

20040093170

Machine vision extracted plant movement for early detection of plant water stress

Kacira, M., Author; Ling, P. P., Author; Short, T. H., Author; Transactions of the ASAE. American Society of Agricultural Engineers; Jul-Aug 2002; ISSN 0001-2351; Volume 45, Issue 4, 1147-53; In English; Copyright; Avail: Other Sources

A methodology was established for early, non-contact, and quantitative detection of plant water stress with machine vision extracted plant features. Top-projected canopy area (TPCA) of the plants was extracted from plant images using image-processing techniques. Water stress induced plant movement was decoupled from plant diurnal movement and plant growth using coefficient of relative variation of TPCA (CRV[TPCA)] and was found to be an effective marker for water stress detection. Threshold value of CRV(TPCA) as an indicator of water stress was determined by a parametric approach. The effectiveness of the sensing technique was evaluated against the timing of stress detection by an operator. Results of this study suggested that plant water stress detection using projected canopy area based features of the plants was feasible.
NLM
Computer Techniques; Computer Vision; Detection; Environmental Control; Environmental Monitoring; Humidity; Image Analysis; Plant Stress; Water

20040087582

Modeling and control for closed environment plant production systems

Fleisher, David H., Author; Ting, K. C., Author; Janes, H. W., Principal Investigator; Acta horticulturae; 2002; ISSN 0567-7572; Volume 593, 85-91; In English
Contract(s)/Grant(s): NGT5-50229; Copyright; Avail: Other Sources

A computer program was developed to study multiple crop production and control in controlled environment plant production systems. The program simulates crop growth and development under nominal and off-nominal environments. Time-series crop models for wheat (Triticum aestivum), soybean (Glycine max), and white potato (Solanum tuberosum) are integrated with a model-based predictive controller. The controller evaluates and compensates for effects of environmental disturbances on crop production scheduling. The crop models consist of a set of nonlinear polynomial equations, six for each crop, developed using multivariate polynomial regression (MPR). Simulated data from DSSAT crop models, previously modified for crop production in controlled environments with hydroponics under elevated atmospheric carbon dioxide concentration, were used for the MPR fitting. The model-based predictive controller adjusts light intensity, air temperature, and carbon dioxide concentration set points in response to environmental perturbations. Control signals are determined from minimization of a cost function, which is based on the weighted control effort and squared-error between the system response and desired reference signal.
NLM
Closed Ecological Systems; Computerized Simulation; Environmental Control; Models; Potatoes; Soybeans; Wheat

20040088247

Solid state 31phosphorus nuclear magnetic resonance of iron-, manganese-, and copper-containing synthetic hydroxyapatites

Sutter, B., Author; Taylor, R. E., Author; Hossner, L. R., Author; Ming, D. W., Author; Soil Science Society of America journal. Soil Science Society of America; Mar-Apr 2002; ISSN 0361-5995; Volume 66, Issue 2, 455-63; In English
Contract(s)/Grant(s): NGT5-1229; Copyright; Avail: Other Sources

The incorporation of micronutrients into synthetic hydroxyapatite (SHA) is proposed for slow release of these nutrients to crops in the National Aeronautics and Space Administration's (NASA's) Advanced Life Support (ALS) program for Lunar or Martian outposts. Solid state 31P nuclear magnetic resonance (NMR) was utilized to examine the paramagnetic effects of Fe^{3+}, Mn^{2+}, and Cu^{2+} to determine if they were incorporated into the SHA structure. Separate Fe^{3+}, Mn^{2+}, and Cu^{2+} containing SHA materials along with a transition metal free SHA (pure-SHA) were synthesized using a precipitation method. The proximity (\h1 nm) of the transition metals to the 31P nuclei of SHA were apparent when comparing the integrated 31P signal intensities of the pure-SHA (87 arbitrary units g-1) with the Fe-, Mn-, and Cu-SHA materials (37-71 arbitrary units g-1). The lower integrated 31P signal intensities of the Fe-, Mn-, and Cu-SHA materials relative to the pure-SHA suggested that Fe^{3+}, Mn^{2+}, and Cu^{2+} were incorporated in the SHA structure. Further support for Fe^{3+}, Mn^{2+}, and Cu^{2+} incorporation was demonstrated by the reduced spin-lattice relaxation constants of the Fe-, Mn-, and Cu-SHA materials (T'=0.075-0.434s) relative to pure-SHA (T1=58.4s). Inversion recovery spectra indicated that Fe^{3+}, Mn^{2+}, and Cu^{2+} were not homogeneously distributed about the 31P nuclei in the SHA structure. Extraction with diethylene-triamine-penta-acetic acid (DTPA) suggested that between 50 and 80% of the total starting metal concentrations were incorporated in the SHA structure. Iron-, Mn-, and Cu-containing SHA are potential slow release sources of Fe, Mn, and Cu in the ALS cropping system.
NLM
Calcium Phosphates; Copper; Iron; Magnetic Resonance Spectroscopy; Manganese; Minerals; Nuclear Magnetic Resonance; Phosphorus; Solid State

20040087496

Sensitivity of wheat and rice to low levels of atmospheric ethylene

Klassen, Stephen P., Author; Bugbee, Bruce, Author; Crop science; May-Jun 2002; ISSN 0011-183X; Volume 42, Issue 3, 746-53; In English; Copyright; Avail: Other Sources

Ethylene (C_2H_4) gas is produced throughout the life cycle of plants and can accumulate in closed growth chambers to levels 100 times higher than in outside environments. Elevated atmospheric C_2H_4 can cause a variety of abnormal responses, but the sensitivity to elevated C_2H_4 is not well characterized. We evaluated the C_2H_4 sensitivity of wheat (Triticum aestivum L.) and rice (Oryza sativa L.) in five studies. The first three studies compared the effects of continuous C_2H_4 levels ranging from 0 to 1000 nmol mol-1 (ppb) in a growth chamber throughout the life cycle of the plants. A short-term 1000 nmol mol-1 treatment was included in which exposure was stopped at anthesis. Yield was reduced by 36% in wheat and 63% in rice at 50 nmol mol-1 and both species were virtually sterile when continuously exposed to 1000 nmol mol-1. However, the yield reductions were much less with exposure that stopped at anthesis, suggesting the detrimental effect of C_2H_4 on yield was greatest around the time of seed set. Two additional studies evaluated the differential sensitivity of two wheat cultivars (Super Dwarf and USU-Apogee) to 50 nmol mol-1 C_2H_4 at three CO_2 levels [350, 1200, 5000 micromoles mol-1 (ppm)] in a greenhouse. Yield of USU-Apogee was not significantly reduced by C_2H_4 but the yield of Super Dwarf was reduced by 60%. Elevated CO_2 did not influence the sensitivity to C_2H_4. A difference in the C_2H_4 sensitivity of USU-Apogee between greenhouse and growth chamber trials suggests that C_2H_4 sensitivity is dependent on the environment. Collectively, the data suggest that relatively low levels of C_2H_4 could induce anomalous plant responses by accumulation in greenhouses and growth chambers with inadequate ventilation. The data also suggest that C_2H_4 sensitivity can be reduced by both genetic and environmental manipulations. 2002 Crop Science Society of America.
NLM
Environmental Control; Ethylene; Plant Growth Regulators; Plants (Botany); Rice; Sensitivity; Wheat

20040087943

Water cycles in closed ecological systems: effects of atmospheric pressure

Rygalov, Vadim Y., Author; Fowler, Philip A., Author; Metz, Joannah M., Author; Wheeler, Raymond M., Author; Bucklin, Ray A., Author; Sager, J. C., Principal Investigator; Life support & biosphere science : international journal of earth space; 2002; ISSN 1069-9422; Volume 8, Issue 3-4, 125-35; In English; Copyright; Avail: Other Sources

In bioregenerative life support systems that use plants to generate food and oxygen, the largest mass flux between the plants and their surrounding environment will be water. This water cycle is a consequence of the continuous change of state (evaporation-condensation) from liquid to gas through the process of transpiration and the need to transfer heat (cool) and dehumidify the plant growth chamber. Evapotranspiration rates for full plant canopies can range from ~1 to 10 L m-2 d-1 (~1 to 10 mm m-2 d-1), with the rates depending primarily on the vapor pressure deficit (VPD) between the leaves and the air inside the plant growth chamber. VPD in turn is dependent on the air temperature, leaf temperature, and current value of relative humidity (RH). Concepts for developing closed plant growth systems, such as greenhouses for Mars, have been discussed for many years and the feasibility of such systems will depend on the overall system costs and reliability. One

approach for reducing system costs would be to reduce the operating pressure within the greenhouse to reduce structural mass and gas leakage. But managing plant growth environments at low pressures (e.g., controlling humidity and heat exchange) may be difficult, and the effects of low-pressure environments on plant growth and system water cycling need further study. We present experimental evidence to show that water saturation pressures in air under isothermal conditions are only slightly affected by total pressure, but the overall water flux from evaporating surfaces can increase as pressure decreases. Mathematical models describing these observations are presented, along with discussion of the importance for considering 'water cycles' in closed bioregenerative life support systems.
NLM
Atmospheric Pressure; Closed Ecological Systems; Cycles; Life Support Systems; Plant Physiology; Pressure Effects; Transpiration; Water

20030067819 NASA Marshall Space Flight Center, Huntsville, AL, USA
A Novel Approach for Modeling Chemical Reaction in Generalized Fluid System Simulation Program
Sozen, Mehmet; Majumdar, Alok; [2002]; In English, 20-23 Jul. 2003, Huntsville, AL, USA; Copyright; Avail: CASI; A01, Hardcopy

The Generalized Fluid System Simulation Program (GFSSP) is a computer code developed at NASA Marshall Space Flight Center for analyzing steady state and transient flow rates, pressures, temperatures, and concentrations in a complex flow network. The code, which performs system level simulation, can handle compressible and incompressible flows as well as phase change and mixture thermodynamics. Thermodynamic and thermophysical property programs, GASP, WASP and GASPAK provide the necessary data for fluids such as helium, methane, neon, nitrogen, carbon monoxide, oxygen, argon, carbon dioxide, fluorine, hydrogen, water, a hydrogen, isobutane, butane, deuterium, ethane, ethylene, hydrogen sulfide, krypton, propane, xenon, several refrigerants, nitrogen trifluoride and ammonia. The program which was developed out of need for an easy to use system level simulation tool for complex flow networks, has been used for the following purposes to name a few: Space Shuttle Main Engine (SSME) High Pressure Oxidizer Turbopump Secondary Flow Circuits, Axial Thrust Balance of the Fastrac Engine Turbopump, Pressurized Propellant Feed System for the Propulsion Test Article at Stennis Space Center, X-34 Main Propulsion System, X-33 Reaction Control System and Thermal Protection System, and International Space Station Environmental Control and Life Support System design. There has been an increasing demand for implementing a combustion simulation capability into GFSSP in order to increase its system level simulation capability of a liquid rocket propulsion system starting from the propellant tanks up to the thruster nozzle for spacecraft as well as launch vehicles. The present work was undertaken for addressing this need. The chemical equilibrium equations derived from the second law of thermodynamics and the energy conservation equation derived from the first law of thermodynamics are solved simultaneously by a Newton-Raphson method. The numerical scheme was implemented as a User Subroutine in GFSSP.
Author
Computer Programs; Computerized Simulation; Chemical Reactions; Liquid Propellant Rocket Engines; Flow Visualization

20040087942
Near-term lander experiments for growing plants on Mars: requirements for information on chemical and physical properties of Mars regolith
Schuerger, Andrew C., Author; Ming, Douglas W., Author; Newsom, Horton E., Author; Ferl, Robert J., Author; McKay, Christopher P., Author; Life support & biosphere science : international journal of earth space; 2002; ISSN 1069-9422; Volume 8, Issue 3-4, 137-47; In English
Contract(s)/Grant(s): NAG5-8804; Copyright; Avail: Other Sources

In order to support humans for long-duration missions to Mars, bioregenerative Advanced Life Support (ALS) systems have been proposed that would use higher plants as the primary candidates for photosynthesis. Hydroponic technologies have been suggested as the primary method of plant production in ALS systems, but the use of Mars regolith as a plant growth medium may have several advantages over hydroponic systems. The advantages for using Mars regolith include the likely bioavailability of plant-essential ions, mechanical support for plants, and easy access of the material once on the surface. We propose that plant biology experiments must be included in near-term Mars lander missions in order to begin defining the optimum approach for growing plants on Mars. Second, we discuss a range of soil chemistry and soil physics tests that must be conducted prior to, or in concert with, a plant biology experiment in order to properly interpret the results of plant growth studies in Mars regolith. The recommended chemical tests include measurements on soil pH, electrical conductivity and soluble salts, redox potential, bioavailability of essential plant nutrients, and bioavailability of phytotoxic elements. In addition, a future plant growth experiment should include procedures for determining the buffering and leaching requirements of Mars regolith prior to planting. Soil physical tests useful for plant biology studies in Mars regolith include bulk density,

particle size distribution, porosity, water retention, and hydraulic conductivity.
NLM
Chemical Properties; Closed Ecological Systems; Life Support Systems; Mars (Planet); Mars Surface; Planetary Geology; Plants (Botany); Regolith; Soils

20040088351
Plant adaptation to low atmospheric pressures: potential molecular responses
Ferl, Robert J., Author; Schuerger, Andrew C., Author; Paul, Anna-Lisa, Author; Gurley, William B., Author; Corey, Kenneth, Author; Bucklin, Ray, Author; Life support & biosphere science : international journal of earth space; 2002; ISSN 1069-9422; Volume 8, Issue 2, 93-101; In English; Copyright; Avail: Other Sources

There is an increasing realization that it may be impossible to attain Earth normal atmospheric pressures in orbital, lunar, or Martian greenhouses, simply because the construction materials do not exist to meet the extraordinary constraints imposed by balancing high engineering requirements against high lift costs. This equation essentially dictates that NASA have in place the capability to grow plants at reduced atmospheric pressure. Yet current understanding of plant growth at low pressures is limited to just a few experiments and relatively rudimentary assessments of plant vigor and growth. The tools now exist, however, to make rapid progress toward understanding the fundamental nature of plant responses and adaptations to low pressures, and to develop strategies for mitigating detrimental effects by engineering the growth conditions or by engineering the plants themselves. The genomes of rice and the model plant Arabidopsis thaliana have recently been sequenced in their entirety, and public sector and commercial DNA chips are becoming available such that thousands of genes can be assayed at once. A fundamental understanding of plant responses and adaptation to low pressures can now be approached and translated into procedures and engineering considerations to enhance plant growth at low atmospheric pressures. In anticipation of such studies, we present here the background arguments supporting these contentions, as well as informed speculation about the kinds of molecular physiological responses that might be expected of plants in low-pressure environments.
NLM
Adaptation; Atmospheric Pressure; Closed Ecological Systems; Life Support Systems; Plant Physiology; Plants (Botany)

20020039615 NASA Kennedy Space Center, Cocoa Beach, FL USA
Membrane Separation Processes at Low Temperatures
Parrish, Clyde; [2002]; In English, 14-17 Jan. 2002, Reno, NV, USA
Report No.(s): NASA/TP-2002-210266; NAS 1.60:210266; AIAA Paper 2002-0461; Copyright; Avail: CASI; A03, Hardcopy

The primary focus of Kennedy Space Center’s gas separation activities has been for carbon dioxide, nitrogen, and argon used in oxygen production technologies for Martian in-situ resource utilization (ISRU) projects. Recently, these studies were expanded to include oxygen for regenerative life support systems. Since commercial membrane systems have been developed for separation of carbon dioxide, nitrogen, and oxygen, initially the studies focused on these membrane systems, but at lower operating temperatures and pressures. Current investigations art examining immobilized liquids and solid sorbents that have the potential for higher selectivity and lower operating temperatures. The gas separation studies reported here use hollow fiber membranes to separate carbon dioxide, nitrogen, and argon in the temperature range from 230 to 300 K. Four commercial membrane materials were used to obtain data at low feed and permeate pressures. These data were used with a commercial solution-diffusion modeling tool to design a system to prepare a buffer gas from the byproduct of a process to capture Martian carbon dioxide. The system was designed to operate, at 230 K with a production rate 0.1 sLpm; Feed composition 30% CO_2, 44% N_2, and 26% Ar; Feed pressure 104 kPa (780); and Permeate pressure 1 kPa (6 torr); Product concentration 600 ppm CO_2. This new system was compared with a similar system designed to operate at ambient temperatures (298 K). The systems described above, along with data, test apparatus, and models are presented.
Author
Low Temperature; Gas Mixtures; Membranes; Systems Engineering; Permeability; Gas Chromatography; Mars (Planet)

20030011414 NASA Marshall Space Flight Center, Huntsville, AL USA
Vapor Compression Distillation Flight Experiment
Hutchens, Cindy F.; STS 107 Shuttle Press Kit: Providing 24/7 Space Science Research; Dec. 16, 2002, 97-99; In English; No Copyright; Avail: CASI; A01, Hardcopy

One of the major requirements associated with operating the International Space Station is the transportation -- space shuttle and Russian Progress spacecraft launches - necessary to re-supply station crews with food and water. The Vapor

Compression Distillation (VCD) Flight Experiment, managed by NASA's Marshall Space Flight Center in Huntsville, Ala., is a full-scale demonstration of technology being developed to recycle crewmember urine and wastewater aboard the International Space Station and thereby reduce the amount of water that must be re-supplied. Based on results of the VCD Flight Experiment, an operational urine processor will be installed in Node 3 of the space station in 2005.
Author
Spaceborne Experiments; Aerospace Technology Transfer; Technology Utilization; Water Reclamation; Urine; Phase Transformations

20040087938
A management information system to study space diets
Kang, Sukwon, Author; Both, A. J., Author; Janes, H. W., Principal Investigator; Life support & biosphere science : international journal of earth space; 2002; ISSN 1069-9422; Volume 8, Issue 3-4, 191-7; In English
Contract(s)/Grant(s): NAGW-5003; Copyright; Avail: Other Sources

A management information system (MIS), including a database management system (DBMS) and a decision support system (DSS), was developed to dynamically analyze the variable nutritional content of foods grown and prepared in an Advanced Life Support System (ALSS) such as required for long-duration space missions. The DBMS was designed around the known nutritional content of a list of candidate crops and their prepared foods. The DSS was designed to determine the composition of the daily crew diet based on crop and nutritional information stored in the DBMS. Each of the selected food items was assumed to be harvested from a yet-to-be designed ALSS biomass production subsystem and further prepared in accompanying food preparation subsystems. The developed DBMS allows for the analysis of the nutrient composition of a sample 20-day diet for future Advanced Life Support missions and is able to determine the required quantities of food needed to satisfy the crew's daily consumption. In addition, based on published crop growth rates, the DBMS was able to calculate the required size of the biomass production area needed to satisfy the daily food requirements for the crew. Results from this study can be used to help design future ALSS for which the integration of various subsystems (e.g., biomass production, food preparation and consumption, and waste processing) is paramount for the success of the mission.
NLM
Decision Support Systems; Diets; Food; Management Information Systems; Plants (Botany)

20020052433 Umpqua Research Co., Myrtle Creek, OR USA
Microgravity Compatible Reagentless Instrumentation for Detection of Dissolved Organic Acids and Alcohols in Potable Water
Akse, James R.; Jan, Darrell L., Technical Monitor; April 2002; In English
Contract(s)/Grant(s): NAG9-1081; No Copyright; Avail: CASI; A05, Hardcopy

The Organic Acid and Alcohol Monitor (OAAM) program has resulted in the successful development of a computer controlled prototype analyzer capable of accurately determining aqueous organic acids and primary alcohol concentrations over a large dynamic range with high sensitivity. Formic, acetic, and propionic acid were accurately determined at concentrations as low as 5 to 10 micrograms/L in under 20 minutes, or as high as 10 to 20 mg/L in under 30 minutes. Methanol, ethanol, and propanol were determined at concentrations as low as 20 to 100 micrograms/L, or as high as 10 mg/L in under 30 minutes. Importantly for space based application, the OAAM requires no reagents or hazardous chemicals to perform these analyses needing only power, water, and CO2 free purge gas. The OAAM utilized two membrane processes to segregate organic acids from interfering ions. The organic acid concentration was then determined based upon the conductiometric signal. Separation of individual organic acids was accomplished using a chromatographic column. Alcohols are determined in a similar manner after conversion to organic acids by sequential biocatalytic and catalytic oxidation steps. The OAAM was designed to allow the early diagnosis of under performing or failing sub-systems within the Water Recovery System (WRS) baselined for the International Space Station (ISS). To achieve this goal, several new technologies were developed over the course of the OAAM program.
Derived from text
Alcohols; Chemical Composition; Potable Water; Analyzers; Prototypes

20030003654 NASA Ames Research Center, Moffett Field, CA USA
Separation of Carbon Monoxide and Carbon Dioxide for Mars ISRU
LeVan, M. Douglas; Walton, Krista S.; Finn, John E.; Sridhar, K. R.; Sixth Microgravity Fluid Physics and Transport Phenomena Conference; November 2002; Volume 1, 620-635; In English; No Copyright; Avail: CASI; A03, Hardcopy

Human Exploration and Development of Space will require the use of fundamental process technologies for gas storage and separation. These are enabling technologies. In our research, we are designing, constructing, and testing an innovative, robust, low mass, low power separation device that can recover carbon dioxide and carbon monoxide for Mars ISRU (in-situ resource utilization). The work has broad implications for gas storage and separations for gas-solid systems; these are ideally suited for reduced gravitational environments. The work is also important for robotic sample return missions using ISRU and in lunar oxygen production from regolith using carbothermal reduction. This paper describes our overall effort and highlights our results on adsorption equilibrium determination and process design. A second paper will provide details on adsorption equilibrium measurement and adsorbent selection.
Author
In Situ Resource Utilization; Mars Exploration; Carbon Dioxide Removal; Carbon Monoxide

20040014970 Lockheed Martin Space Mission Systems and Services, Houston, TX, USA, NASA Ames Research Center, Moffett Field, CA, USA
Oxygen Penalty for Waste Oxidation in an Advanced Life Support System: A Systems Approach
Pisharody, Suresh; Wignarajah, K.; Fisher, John; [2002]; In English, 15-18 Jul. 2002, San Antonio, TX, USA; Original contains black and white illustrations
Contract(s)/Grant(s): NAS2-14263
Report No.(s): SAE-2002-01-2396; Copyright; Avail: CASI; A02, Hardcopy
Oxidation is one of a number of technologies that are being considered for waste management and resource recovery from waste materials generated on board space missions. Oxidation processes are a very effective and efficient means of clean and complete conversion of waste materials to sterile products. However, because oxidation uses oxygen there is an 'oxygen penalty' associated either with resupply of oxygen or with recycling oxygen from some other source. This paper is a systems approach to the issue of oxygen penalty in life support systems and presents findings on the oxygen penalty associated with an integrated oxidation-Sabatier-Oxygen Generation System (OGS) for waste management in an Advanced Life Support System. The findings reveal that such an integrated system can be operated to form a variety of useful products without a significant oxygen penalty.
Author
Oxygen Supply Equipment; Life Support Systems; Waste Management; Recycling; Oxidation

20040087983
A model for plant lighting system selection
Ciolkosz, D. E., Author; Albright, L. D., Author; Sager, J. C., Author; Langhans, R. W., Author; Transactions of the ASAE. American Society of Agricultural Engineers; Jan-Feb 2002; ISSN 0001-2351; Volume 45, Issue 1, 215-21; In English; Copyright; Avail: Other Sources
A decision model is presented that compares lighting systems for a plant growth scenario and chooses the most appropriate system from a given set of possible choices. The model utilizes a Multiple Attribute Utility Theory approach, and incorporates expert input and performance simulations to calculate a utility value for each lighting system being considered. The system with the highest utility is deemed the most appropriate system. The model was applied to a greenhouse scenario, and analyses were conducted to test the model's output for validity. Parameter variation indicates that the model performed as expected. Analysis of model output indicates that differences in utility among the candidate lighting systems were sufficiently large to give confidence that the model's order of selection was valid.
NLM
Decision Making; Decision Support Systems; Environmental Control; Illuminating; Light (Visible Radiation); Models; Plants (Botany)

20040008395 Lockheed Martin Space Operations, Bay Saint Louis, MS, USA
Oxygen Mass Flow Rate Generated for Monitoring Hydrogen Peroxide Stability
Ross, H. Richard; September 15, 2002; In English, 15-19 Sep. 2002, Indianapolis, IN, USA
Contract(s)/Grant(s): NAS13-650
Report No.(s): SE-2002-09-00064-SSC; No Copyright; Avail: CASI; A02, Hardcopy
Recent interest in propellants with non-toxic reaction products has led to a resurgence of interest in hydrogen peroxide for various propellant applications. Because peroxide is sensitive to contaminants, material interactions, stability and storage issues, monitoring decomposition rates is important. Stennis Space Center (SSC) uses thermocouples to monitor bulk fluid

temperature (heat evolution) to determine reaction rates. Unfortunately, large temperature rises are required to offset the heat lost into the surrounding fluid. Also, tank penetration to accomodate a thermocouple can entail modification of a tank or line and act as a source of contamination. The paper evaluates a method for monitoring oxygen evolution as a means to determine peroxide stability. Oxygen generation is not only directly related to peroxide decomposition, but occurs immediately. Measuring peroxide temperature to monitor peroxide stability has significant limitations. The bulk decomposition of 1% / week in a large volume tank can produce in excess of 30 cc / min. This oxygen flow rate corresponds to an equivalent temperature rise of approximately 14 millidegrees C, which is difficult to measure reliably. Thus, if heat transfer were included, there would be no temperature rise. Temperature changes from the surrounding environment and heat lost to the peroxide will also mask potential problems. The use of oxygen flow measurements provides an ultra sensitive technique for monitoring reaction events and will provide an earlier indication of an abnormal decomposition when compared to measuring temperature rise.
Author
Hydrogen Peroxide; Mass Flow Rate; Stability; Chemical Evolution; Oxygen

20040113586

[The ecology of microorganisms in closed environments--existing state and problems]

Koike, J., Author; Uchu seibutsu kagaku; Oct 2001; ISSN 0914-9201; Volume 15, Issue 3, 238; In Japanese; Copyright; Avail: Other Sources

No abstract available

Closed Ecological Systems; Ecology; Microbiology; Microorganisms

20040115496

Formation of higher plant component microbial community in closed ecological system

Tirranen, L. S., Author; Acta astronautica; Jul 2001; ISSN 0094-5765; Volume 49, Issue 1, 47-52; In English; Copyright; Avail: Other Sources

Closed ecological systems (CES) place at the disposal of a researcher unique possibilities to study the role of microbial communities in individual components and of the entire system. The microbial community of the higher plant component has been found to form depending on specific conditions of the closed ecosystem: length of time the solution is reused, introduction of intrasystem waste water into the nutrient medium, effect of other component of the system, and system closure in terms of gas exchange. The higher plant component formed its own microbial complex different from that formed prior to closure. The microbial complex of vegetable polyculture is more diverse and stable than the monoculture of wheat. The composition of the components' microflora changed, species diversity decreased, individual species of bacteria and fungi whose numbers were not so great before the closure prevailed. Special attention should be paid to phytopathogenic and conditionally pathogenic species of microorganisms potentially hazardous to man or plants and the least controlled in CES. This situation can endanger creation of CES and make conjectural existence of preplanned components, man, specifically, and consequently, of CES as it is. c2001 International Astronautical Federation. Published by Elsevier Science Ltd.
NLM
Closed Ecological Systems; Life Support Systems; Liquid Wastes; Microbiology; Microorganisms; Plant Roots; Waste Disposal

20010067773 NASA Marshall Space Flight Center, Huntsville, AL USA

Investigation into the Performance of Membrane Separator Technologies Used in the International Space Station Regenerative Life Support Systems: Results and Lessons Learned

Holder, Donald W.; OConnor, Edward W.; Zagaja, John; Murdoch, Karen; Croomes, Scott D., Technical Monitor; [2001]; In English; 31st ICES Conference, 9-12 Jul. 2001, Orlando, FL, USA
Report No.(s): SAE-2001-01-2354; Copyright; Avail: Other Sources

The Volatile Removal Assembly Flight Experiment (VRAFE) was performed in May of 1999, on board Shuttle Flight STS-96 to support the development of the International Space Station (ISS) Water Recovery System (WRS). The objective of this experiment was to address concerns in the performance of a two-phase, catalytic reactor in a microgravity environment. During the experiment, an unexpected finding was discovered when the VRAFE Gas/Liquid Separator (GLS) failed to separate gas from the reactor outlet stream. The VRAFE GLS was a two-membrane (flat sheet hydrophobic and hydrophilic membrane) gas trap. Flight data as well as the post-flight failure investigation determined that the GLS hydrophobic membrane failed as a result of very fine hydrophilic catalyst particles from the VRAFE reactor that had contaminated the surface of the

hydrophobic membrane. These particles allowed a water layer to wick across the surface of the hydrophobic membrane and effectively block the pores from passing gas. Microgravity magnified the failure effect since there was no gravity to free drain the water layer from the hydrophobic membrane. Though this GLS design was not the VRA flight design, a hydrophobic membrane separator is used in the VRA and other membrane separators are used throughout the ISS life support systems. As a result of the GLS failure, an assessment of all the membrane separators in the water recycling and oxygen generation systems was performed to determine if membrane separation was acceptable in each application. This paper summarizes the results and lessons learned from this investigation.
Author
Life Support Systems; International Space Station; Membranes; Separators; Microgravity

20040118212
Earth life support for aquatic organisms, system and technical aspects
Konig, B., Author; Dunne, M., Author; Slenzka, K., Author; Advances in space research : the official journal of the Committee on Space Research (COSPAR); 2001; Volume 27, Issue 9, 1523-8; In English; Copyright; Avail: Other Sources

The importance of the research on Bioregenerative Life Support has increased dramatically in the last decade not only with regard to possible space flight application but also as a way to obtain a better understanding of our Earth's ecology. A major goal was to reach long-term stability of artificial model systems. Preliminary data are presented on the development of an improved aquatic system, currently dedicated for ground-based research. Closed aquatic ecosystems require reliability of the key parameters of pH, O2 and CO2 concentration and stability of sensors for monitoring. Besides the integration of an artificial lung (holofiber system and air pump with valves, allowing controlled oxygen uptake of air), in parallel to the oxygen producing water plants. Our new approach is to implement opto-chemical sensors, for such environmental monitoring. One major advantage of the new sensor technique is their better long-term reliability as compared to the electrochemical sensors. Our experiment with the new sensor technique has demonstrated satisfactory performance in closed aquatic ecosystems. c 2001. COSPAR. Published by Elsevier Science Ltd. All rights reserved.
NLM
Aquiculture; Closed Ecological Systems; Environmental Monitoring; Life Support Systems; Marine Biology; Organisms; Oxygen; Support Systems

20040088685
Issues in life support and human factors in crew rescue from the ISS
Smart, K., Author; Life support & biosphere science : international journal of earth space; 2001; ISSN 1069-9422; Volume 7, Issue 4, 319-25; In English; Copyright; Avail: Other Sources

The design and development of crew emergency response systems, particularly to provide an unplanned emergency return to Earth, requires an understanding of crew performance challenges in space. The combined effects of psychological and physiological adaptation during long-duration missions will have a significant effect on crew performance in the unpredictable and potentially life-threatening conditions of an emergency return to Earth. It is therefore important that the systems to be developed for emergency egress address these challenges through an integrated program to produce optimum productivity and safety in times of utmost stress. Fundamental to the success of the CRV is the Environmental Control and Life Support System (ECLSS), which provides the necessary conditions for the crew to survive their return mission in a shirtsleeve environment. This article will discuss the many issues in the design of an ECLSS system for CRV and place it in the context of the human performance challenges of the mission.
NLM
Human Factors Engineering; Life Support Systems; Rescue Operations; Weightlessness

20040088736
Reverse osmosis filtration for space mission wastewater: membrane properties and operating conditions
Lee, S., Author; Lueptow, R. M., Author; Journal of membrane science; Feb 2001; ISSN 0376-7388; Volume 182, Issue 1-2, 77-90; In English; Copyright; Avail: Other Sources

Reverse osmosis (RO) is a compact process that has potential for the removal of ionic and organic pollutants for recycling space mission wastewater. Seven candidate RO membranes were compared using a batch stirred cell to determine the membrane flux and the solute rejection for synthetic space mission wastewaters. Even though the urea molecule is larger than ions such as Na+, Cl-, and NH4+, the rejection of urea is lower. This indicates that the chemical interaction between solutes and the membrane is more important than the size exclusion effect. Low pressure reverse osmosis (LPRO) membranes appear

to be most desirable because of their high permeate flux and rejection. Solute rejection is dependent on the shear rate, indicating the importance of concentration polarization. A simple transport model based on the solution-diffusion model incorporating concentration polarization is used to interpret the experimental results and predict rejection over a range of operating conditions. Grant numbers: NAG 9-1053.
NLM
Closed Ecological Systems; Filtration; Membranes; Reverse Osmosis; Space Missions; Waste Management; Water Treatment

20010027421 NASA Kennedy Space Center, Cocoa Beach, FL USA
Buffer Gas Acquisition and Storage
Parrish, Clyde F.; Lueck, Dale E.; Jennings, Paul A.; Callahan, Richard A.; Delgado, H., Technical Monitor; [2001]; In English; Space Technology, 11-14 Feb. 2001, Albuquerque, NM, USA; No Copyright; Avail: CASI; A02, Hardcopy

The acquisition and storage of buffer gases (primarily argon and nitrogen) from the Mars atmosphere provides a valuable resource for blanketing and pressurizing fuel tanks and as a buffer gas for breathing air for manned missions. During the acquisition of carbon dioxide (CO2), whether by sorption bed or cryo-freezer, the accompanying buffer gases build up in the carbon dioxide acquisition system, reduce the flow of CO2 to the bed, and lower system efficiency. It is this build up of buffer gases that provide a convenient source, which must be removed, for efficient capture Of CO2 Removal of this buffer gas barrier greatly improves the charging rate of the CO2 acquisition bed and, thereby, maintains the fuel production rates required for a successful mission. Consequently, the acquisition, purification, and storage of these buffer gases are important goals of ISRU plans. Purity of the buffer gases is a concern e.g., if the CO, freezer operates at 140 K, the composition of the inert gas would be approximately 21 percent CO2, 50 percent nitrogen, and 29 percent argon. Although there are several approaches that could be used, this effort focused on a hollow-fiber membrane (HFM) separation method. This study measured the permeation rates of CO2, nitrogen (ND, and argon (Ar) through a multiple-membrane system and the individual membranes from room temperature to 193K and 10 kpa to 300 kPa. Concentrations were measured with a gas chromatograph that used a thermoconductivity (TCD) detector with helium (He) as the carrier gas. The general trend as the temperature was lowered was for the membranes to become more selective, In addition, the relative permeation rates between the three gases changed with temperature. The end result was to provide design parameters that could be used to separate CO2 from N2 and Ar.
Author
Buffer Storage; Acquisition; Mars Atmosphere; Argon; Nitrogen

20010029206 NASA Kennedy Space Center, Cocoa Beach, FL USA
A Survey of Alternative Oxygen Production Technologies
Lueck, Dale E.; Parrish, Clyde F.; Buttner, William J.; Surma, Jan M.; Delgado, H., Technical Monitor; [2001]; In English; Space Technology and International Forum, 11-14 Feb. 2001, Albuquerque, NM, USA; No Copyright; Avail: CASI; A02, Hardcopy

Utilization of the Martian atmosphere for the production of fuel and oxygen has been extensively studied. The baseline fuel production process is a Sabatier reactor, which produces methane and water from carbon dioxide and hydrogen. The oxygen produced from the electrolysis of the water is only half of that needed for methane-based rocket propellant, and additional oxygen is needed for breathing air, fuel cells and other energy sources. Zirconia electrolysis cells for the direct reduction of CO2 arc being developed as an alternative means of producing oxygen, but present many challenges for a large-scale oxygen production system. The very high operating temperatures and fragile nature of the cells coupled with fairly high operating voltages leave room for improvement. This paper will survey alternative oxygen production technologies, present data on operating characteristics, materials of construction, and some preliminary laboratory results on attempts to implement each. Our goal is to significantly improve upon the characteristics of proposed zirconia cells for oxygen production. To achieve that goal we are looking at electrolytic systems that operate at significantly lower temperatures, preferably below 31C to allow the incorporation of liquid CO2 in the electrolyte. Our preliminary results indicate that such a system will have much higher current densities and have simpler cathode construction than a porous gas feed electrode system. Such a system could be achieved based on nonaqueous electrolytes or ionic liquids. We are focusing our research on the anode reaction that will produce oxygen from a product generated at the cathode using CO2 as the feed. Operation at low temperatures also will open up the full range of polymer and metal materials, allowing a more robust system design to withstand the rigors of flight, landing, and long term unattended operation on the surface of Mars.
Author
Mars Atmosphere; Carbon Dioxide; Fuel Cells; Fuel Production; Nonaqueous Electrolytes; Oxygen Production; Rocket Propellants

20040118210

Manipulating light and temperature to minimize environmental stress in the plant component of bioregenerative life support systems

Tikhomirov, A. A., Author; Ushakova, S. A., Author; Advances in space research : the official journal of the Committee on Space Research (COSPAR); 2001; Volume 27, Issue 9, 1535-9; In English; Copyright; Avail: Other Sources

Our experiments examined enhancing tolerance of the photosynthesizing component to possible deviations in thermal or illumination conditions inside a bioregenerative life support system (BLSS). In the event of one parameter getting beyond its optimum, the values of other parameters may ensure minimal damage to the plant component during the period of environmental stress. With wheat plants (one of key elements of the plant component) as an example the work considers whether it is possible to enhance thermal tolerance by varying light intensity. Increase of air temperature to 35 degrees C or 45 degrees C with light intensity of 60 W/m2 PAR has been shown to substantially inhibit the photosynthesis processes; at 150 W/m2 PAR photosynthesis decreases from 50% to 100%, respectively; when light intensity is increased to 240 W/m2 PAR photosynthesis increased more than 70% at 35 degrees C and decreased at 45 degrees C by only 20%. Thus, light intensity can be increased to avoid or decrease the inhibiting effect of high temperatures. On the other hand, tolerance of wheat plants to prolonged absence of light can be substantially enhanced by decreasing during this period air temperature to temperatures close to 0 degrees C. c 2001. COSPAR. Published by Elsevier Science Ltd. All rights reserved.

NLM

Closed Ecological Systems; Environment Effects; Life Support Systems; Light (Visible Radiation); Stresses; Temperature; Wheat

20040115490

Potential and benefits of closed loop ECLS systems on the ISS

Raatschen, W., Author; Preiss, H., Author; Acta astronautica; Mar-Jun 2001; ISSN 0094-5765; Volume 48, Issue 5-12, 411-9; In English; Copyright; Avail: Other Sources

To close open loops for long manned missions in space is a big challenge for aeronautic engineers throughout the world. The paper's focus is on the oxygen reclamation from carbon dioxide within a space habitat. A brief description of the function principle of a fixed alkaline electrolyzer, a solid amine carbon dioxide concentrator and a Sabatier reactor is given. By combining these devices to an air revitalization system the technical and economical benefits are explained. Astrium's Air Revitalization System (ARES) as a potential future part of the International Space Station's Environmental Control and Life Support System would close the oxygen loop. The amount of oxygen, needed for an ISS crew of seven astronauts could be provided by ARES. The upload of almost 1500 kg of water annually for oxygen generation through the onboard electrolyzer would be reduced by more than 1000 kg, resulting in savings of more than 30M$ per year. Additionally, the payload capacity of supply flights would be increased by this amount of mass. Further possibilities are addressed to combine ECLS mass flows with those of the power, propulsion and attitude control systems. Such closed loop approaches will contribute to ease long time missions (e. g. Mars, Moon) from a cost and logistic point of view. The hardware realization of Astrium's space-sized operating ARES is shown and test results of continuous and intermittent closed chamber tests are presented. c2001 Astrium GmbH. Published by Elsevier Science Ltd.

NLM

Air Conditioning; Closed Ecological Systems; Feedback Control; Life Support Systems; Weightlessness

20020016718 NASA Marshall Space Flight Center, Huntsville, AL USA

Space Station Environmental Control and Life Support System Purge Control Pump Assembly Modeling and Analysis

Schunk, R. Gregory; Hunt, Patrick L., Technical Monitor; [2001]; In English; Thermal and Fluids Analysis Workshop, 10-14 Sep. 2001, Huntsville, AL, USA; No Copyright; Avail: CASI; A03, Hardcopy

Preliminary results from a thermal/flow analysis of the Purge Control Pump Assembly (PCPA) indicate that pump performance (mass flow rate) is enhanced via cooling of the housing and lowering of the inlet vapor quality. Under a nominal operational profile (25% duty cycle or less), at the maximum motor dissipation, it appears that the peristaltic tubing temperature will still remain significantly below the expected UPA condenser temperature (78 F max versus approximately 105 F in the condenser) permitting condensation in the pump head.

Derived from text

Environmental Control; Life Support Systems; Thermal Analysis; Pumps; Computerized Simulation

20040123550

Feasibility of the membrane bioreactor process for water reclamation

Adham, S., Author; Gagliardo, P., Author; Boulos, L., Author; Oppenheimer, J., Author; Trussell, R., Author; Water science and technology : a journal of the International Association on Water Pollution Research; 2001; ISSN 0273-1223; Volume 43, Issue 10, 203-9; In English; Copyright; Avail: Other Sources

The feasibility of the membrane bioreactor (MBR) process for water reclamation was studied. Process evaluation was based on the following: literature review of MBRs, worldwide survey of MBRs, and preliminary costs estimates. The literature review and the survey have shown that the MBR process offers several benefits over the conventional activated sludge process, including: smaller space and reactor requirements, better effluent water quality, disinfection, increased volumetric loading, and less sludge production. The MBR process can exist in two different configurations, one with the low-pressure membrane modules replacing the clarifier downstream the bioreactor (in series), and the second with the membranes submerged within the bioreactor. Four major companies are currently marketing MBRs while many other companies are also in the process of developing new MBRs. The MBR process operates in a considerably different range of parameters than the conventional activated sludge process. The preliminary cost evaluation has shown that the MBR process is cost competitive with other conventional wastewater treatment processes.

NLM

Bioreactors; Earth Resources; Economics; Filtration; Membranes; Water Reclamation; Water Treatment

20010069995 NASA Marshall Space Flight Center, Huntsville, AL USA

International Space Station Environmental Control and Life Support System Status: 2000-2001

Reuter, James L.; Reysa, Richard; Croomes, Scott, Technical Monitor; [2001]; In English; 31st ICES Conference, 9-12 Jul. 2001, Orlando, FL, USA

Report No.(s): SAE-2001-01-2386; Copyright; Avail: Other Sources

The International Space Station (ISS) Environmental Control and Life Support (ECLS) system includes regenerative and non-regenerative technologies that provide the basic life support functions to support the crew, while maintaining a safe and habitable shirtsleeve environment. This paper provides a summary of the U.S. ECLS system activities over the past year, covering the period of time between May 2000 and April 2001. Significant progress was made on assembly of the ISS, with permanent crew occupation established in November 2000. The Phase 2 portion of the assembly has just one additional flight scheduled prior to completion, with Flight 7A scheduled to bring the Airlock in June 2001. ISS budget limitations, which are still not completely resolved, have led to a reassessment of the late Phase 3 elements schedule and eventual growth to a seven person crew. The Node 3 regenerative ECLS design activities have continued with flight component manufacturing initiated. However, the delivery schedule to the Kennedy Space Center (KSC) for element integration has been delayed by 12 months. The Propulsion Module has been removed from assembly planning, while negotiations have begun to consider increased international participation in the Habitation Module and Crew Rescue Vehicle development.

Author

Environmental Control; Life Support Systems; International Space Station; Air Locks

20020050609 Florida Inst. of Tech., FL USA

Operation, Modeling and Analysis of the Reverse Water Gas Shift Process

Whitlow, Jonathan E.; NASA/ASEE Summer Faculty Fellowship Program; October 2001, 189-198; In English

Contract(s)/Grant(s): NAG10-299; No Copyright; Avail: CASI; A02, Hardcopy

The Reverse Water Gas Shift process is a candidate technology for water and oxygen production on Mars under the In-Situ Propellant Production project. This report focuses on the operation and analysis of the Reverse Water Gas Shift (RWGS) process, which has been constructed at Kennedy Space Center. A summary of results from the initial operation of the RWGS, process along with an analysis of these results is included in this report. In addition an evaluation of a material balance model developed from the work performed previously under the summer program is included along with recommendations for further experimental work.

Author

Material Balance; Oxygen Production; Propellants

20040113100

Design and development of an automated and non-contact sensing system for continuous monitoring of plant health and growth

Kacira, M., Author; Ling, P. P., Author; Transactions of the ASAE. American Society of Agricultural Engineers; Jul-Aug 2001; ISSN 0001-2351; Volume 44, Issue 4, 989-96; In English; Copyright; Avail: Other Sources

An automated system was designed and built to continuously monitor plant health and growth in a controlled environment using a distributed system approach for operational control and data collection. The computer-controlled system consisted of a motorized turntable to present the plants to the stationary sensors and reduce microclimate variability among the plants. Major sensing capabilities of the system included machine vision, infrared thermometry, time domain reflectometry, and micro-lysimeters. The system also maintained precise growth-medium moisture levels through a computer-controlled drip irrigation system. The system was capable of collecting required data continuously to monitor and to evaluate the plant health and growth.

NLM

Closed Ecological Systems; Detection; Environmental Monitoring; Health; Life Support Systems; Microclimatology; Plant Physiology; Plants (Botany); Signal Processing; Vegetation Growth

20040088753

Low power, lightweight vapor sensing using arrays of conducting polymer composite chemically-sensitive resistors

Ryan, M. A., Author; Lewis, N. S., Author; Enantiomer; 2001; ISSN 1024-2430; Volume 6, Issue 2-3, 159-70; In English; Copyright; Avail: Other Sources

Arrays of broadly responsive vapor detectors can be used to detect, identify, and quantify vapors and vapor mixtures. One implementation of this strategy involves the use of arrays of chemically-sensitive resistors made from conducting polymer composites. Sorption of an analyte into the polymer composite detector leads to swelling of the film material. The swelling is in turn transduced into a change in electrical resistance because the detector films consist of polymers filled with conducting particles such as carbon black. The differential sorption, and thus differential swelling, of an analyte into each polymer composite in the array produces a unique pattern for each different analyte of interest, Pattern recognition algorithms are then used to analyze the multivariate data arising from the responses of such a detector array. Chiral detector films can provide differential detection of the presence of certain chiral organic vapor analytes. Aspects of the spaceflight qualification and deployment of such a detector array, along with its performance for certain analytes of interest in manned life support applications, are reviewed and summarized in this article.

NLM

Air Conditioning; Conducting Polymers; Detection; Environmental Monitoring; Gases; Life Support Systems; Polymers; Resistors; Sensitivity; Vapors

20010057286 NASA Marshall Space Flight Center, Huntsville, AL USA

CO2 Acquisition Membrane (CAM) Project

Mason, L. W.; Way, J. D.; Vlasse, M.; Microgravity Materials Science Conference 2000; March 2001; Volume 2, 411-412; In English; CD-ROM contains the entire Conference Proceedings presented in PDF format; No Copyright; Avail: CASI; A01, Hardcopy

The CO2 Acquisition Membrane (CAM) project will develop, test, and analyze membrane materials for separation and purification of carbon dioxide (CO2) from mixtures of gases, such as those found in the Martian atmosphere. The CAM technology will enable passive separation of these gases, allow energy efficient acquisition and purification of these important resources, and lay the foundation for future unmanned sample return and human space missions. The CAM membranes are targeted toward In Situ Resource Utilization (ISRU) applications, such as In Situ Propellant Production (ISPP) and In Situ Consumables Production (ISCP).

Author

Carbon Dioxide Removal; Gas Mixtures; Mars (Planet)

20040117169

The Martian and extraterrestrial UV radiation environment. Part II: further considerations on materials and design criteria for artificial ecosystems

Cockell, C. S., Author; Acta astronautica; Dec 2001; ISSN 0094-5765; Volume 49, Issue 11, 631-40; In English; Copyright; Avail: Other Sources

Ultraviolet radiation is an important natural physical influence on organism function and ecosystem interactions. The UV radiation fluxes in extraterrestrial environments are substantially different from those experienced on Earth. On Mars, the moon and in Earth orbit they are more biologically detrimental than on Earth. Based on previously presented fluxes and biologically weighted irradiances, this paper considers in more detail measures to mitigate UV radiation damage and methods to modify extraterrestrial UV radiation environments in artificial ecosystems that use natural sunlight. The transmission characteristics of a Martian material that will mimic the terrestrial UV radiation environment are presented. Transmissivity characteristics of other Martian and lunar materials are described. Manufacturing processes for the production of plastics and glass on the lunar and Martian surface are presented with special emphasis on photobiological requirements. Novel UV absorbing configurations are suggested.

NLM

Closed Ecological Systems; Design Analysis; Ecosystems; Extraterrestrial Environments; Extraterrestrial Radiation; Mars (Planet); Radiation Protection; Ultraviolet Radiation

20040088339

[Pre-flight ground studies for the Water Offset Nutrient Delivery Experiment (WONDER): a spaceflight payload comparing two nutrient delivery systems for plant growth in space]

Kasahara, H., Author; Levine, L., Author; Tynes, G. K., Author; Levine, H. G., Author; Uchu seibutsu kagaku; Oct 2001; ISSN 0914-9201; Volume 15, Issue 3, 232-3; In Japanese; Copyright; Avail: Other Sources

No abstract available

Closed Ecological Systems; Delivery; Environmental Control; Hydroponics; Life Support Systems; Payloads; Space Flight; Vegetation Growth; Water

20040119094

Effect of volatile metabolites of dill, radish and garlic on growth of bacteria

Tirranen, L. S., Author; Borodina, E. V., Author; Ushakova, S. A., Author; Rygalov, V. Y., Author; Gitelson, J. I., Author; Acta astronautica; Jul 2001; ISSN 0094-5765; Volume 49, Issue 2, 105-8; In English; Copyright; Avail: Other Sources

In a model experiment plants were grown in sealed chambers on expanded clay aggregate under the luminance of 150 W/m2 PAR and the temperature of 24 degrees C. Seven bacterial strains under investigation, replicated on nutrient medium surface in Petri dishes, were grown in the atmosphere of cultivated plants. Microbial response was evaluated by the difference between colony size in experiment and in control. In control, bacteria grew in the atmosphere of clean air. To study the effects of volatile metabolites of various plant on microbial growth, the experimental data were compared with the background values defined for each individual experiment. Expanded clay aggregate, luminance, temperature, and sealed chamber (without plants) for the background were the same. Volatile metabolites from 28-days old radish plants have been reliably established to have no effect on the growth of microbes under investigation. Metabolites of 30-days old dill and 50-days old garlic have been established to have reliable bacteriostatic effect on the growth of three bacterial strains. Dill and garlic have been found to have different range of effects of volatile substances on bacterial growth. Volatile metabolites of dill and garlic differed in their effect on the sensitivity spectrum of bacteria. An attempt has been made to describe the obtained data mathematically.

NLM

Bacteria; Closed Ecological Systems; Metabolites; Plants (Botany); Vegetables

20040118628

ESA developments in life support technology: achievements and future priorities

Savage, C. J., Author; Tan, G. B., Author; Lasseur, C., Author; Acta astronautica; Aug-Nov 2001; ISSN 0094-5765; Volume 49, Issue 3-10, 331-44; In English; Copyright; Avail: Other Sources

Following an enthusiastic start in 1985, ESA’s life support technology development programme was re-assessed in the mid- to late-1990s to reflect the strong reduction in European manned space ambitions which occurred at that time. Further development was essentially restricted to activities that could constitute ISS upgrades or enhancements, or support ISS utilisation/operations, together with a single, limited, activity (MELISSA) aimed at bioregenerative life support, in the continuing hope that there might be ‘life after Station’. The paper describes the current status of these activities and summarises the main priorities for future development that were identified at the April 1999 Workshop on Advanced Life Support.

NLM

Air Conditioning; Closed Ecological Systems; Environmental Monitoring; European Space Agency; Life Support Systems; Priorities

20040118216

Space life sciences: closed ecological systems: Earth and space applications. Proceedings of the F4.4 Symposium of COSPAR Scientific Commission F which was held during the Thirty-third COSPAR Scientific Assembly, Warsaw, Poland, July, 2000

Advances in space research : the official journal of the Committee on Space Research (COSPAR); 2001; Volume 27, Issue 9, 1495-617; In English; Copyright; Avail: Other Sources

No abstract available

Closed Ecological Systems; Conferences; Life Support Systems; Poland; Technology Utilization; Weightlessness

20040118213

Aquatic food production modules in bioregenerative life support systems based on higher plants

Bluem, V., Author; Paris, F., Author; Advances in space research : the official journal of the Committee on Space Research (COSPAR); 2001; Volume 27, Issue 9, 1513-22; In English; Copyright; Avail: Other Sources

Most bioregenerative life support systems (BLSS) are based on gravitropic higher plants which exhibit growth and seed generation disturbances in microgravity. Even when used for a lunar or martian base the reduced gravity may induce a decreased productivity in comparison to Earth. Therefore, the implementation of aquatic biomass production modules in higher plant and/or hybrid BLSS may compensate for this and offer, in addition, the possibility to produce animal protein for human nutrition. It was shown on the SLS-89 and SLS-90 space shuttle missions with the C.E.B.A.S.-MINI MODULE that the edible non gravitropic rootless higher aquatic plant Ceratophyllum demeresum exhibits an undisturbed high biomass production rate in space and that the teleost fish species, Xiphophorus helleri, adapts rapidly to space conditions without loss of its normal reproductive functions. Based on these findings a series of ground-based aquatic food production systems were developed which are disposed for utilization in space. These are plant production bioreactors for the species mentioned above and another suitable candidate, the lemnacean (duckweed) species, Wolffia arrhiza. Moreover, combined intensive aquaculture systems with a closed food loop between herbivorous fishes and aquatic and land plants are being developed which may be suitable for integration into a BLSS of higher complexity. Grant numbers: WS50WB9319-3, IVA1216-00588. c 2001. COSPAR. Published by Elsevier Science Ltd. All rights reserved.

NLM

Aquiculture; Closed Ecological Systems; Life Support Systems; Modules; Weightlessness

20040102923

[Development and clinical application of the full automatic animal rearing cabin of low oxygen and high carbon dioxide]

Chong, Y. B., Author; Qi, Y. G., Author; Qian, G. S., Author; Zhang, X. Q., Author; Yao, W., Author; Zhao, Z. Q., Author; Shi, C. N., Author; Zhongguo yi liao qi xie za zhi = Chinese journal of medical instrumentation; Jan 2001; ISSN 1000-6974; Volume 25, Issue 1, 36-8; In Chinese; Copyright; Avail: Other Sources

This paper introduces a kind of automatic animal rearing cabin of low oxygen and high carbon dioxide. It can mimic the environment of low oxygen and high carbon dioxide at atmospheric pressure and automatically measure and control the concentrations of oxygen and carbon dioxide as well as temperature and humidity in the cabin. The system may provide the equipment support for clinical COPD study. The clinical applications show that the cabin with accurate measurement and control is practical and reliable.

NLM

Air Conditioning; Animals; Carbon Dioxide; Closed Ecological Systems; Life Support Systems; Oxygen

20040088438

Plants, plant pathogens, and microgravity--a deadly trio

Leach, J. E., Author; Ryba-White, M., Author; Sun, Q., Author; Wu, C. J., Author; Hilaire, E., Author; Gartner, C., Author; Nedukha, O., Author; Kordyum, E., Author; Keck, M., Author; Leung, H., Author; Guikema, J. A., Author; Gravitational and space biology bulletin : publication of the American Society for Gravitational and Space Biology; Jun 2001; ISSN 1089-988X; Volume 14, Issue 2, 15-23; In English

Contract(s)/Grant(s): NAG10-142; NCC5-168; Copyright; Avail: Other Sources

Plants grown in spaceflight conditions are more susceptible to colonization by plant pathogens. The underlying causes for this enhanced susceptibility are not known. Possibly the formation of structural barriers and the activation of plant defense response components are impaired in spaceflight conditions. Either condition would result from altered gene expression of the plant. Because of the tools available, past studies focused on a few physiological responses or biochemical pathways. With recent advances in genomics research, new tools, including microarray technologies, are available to examine the global impact of growth in the spacecraft on the plant's gene expression profile. In ground-based studies, we have developed cDNA subtraction libraries of rice that are enriched for genes induced during pathogen infection and the defense response. Arrays of these genes are being used to dissect plant defense response pathways in a model system involving wild-type rice plants and lesion mimic mutants. The lesion mimic mutants are ideal experimental tools because they erratically develop defense response-like lesions in the absence of pathogens. The gene expression profiles from these ground-based studies will provide the molecular basis for understanding the biochemical and physiological impacts of spaceflight on plant growth, development and disease defense responses. This, in turn, will allow the development of strategies to manage plant disease for life in the space environment.

NLM

Gene Expression Regulation; Microgravity; Pathogens; Plant Diseases; Plants (Botany); Weightlessness

20040118206

Functional, regulatory and indicator features of microorganisms in man-made ecosystems

Somova, L. A., Author; Pechurkin, N. S., Author; Advances in space research : the official journal of the Committee on Space Research (COSPAR); 2001; Volume 27, Issue 9, 1563-70; In English; Copyright; Avail: Other Sources

Functional, regulatory and indicator features of microorganisms in development and functioning of the systems and sustaining stability of three man-made ecosystem types has been studied. 1) The functional (metabolic) feature was studied in aquatic ecosystems of biological treatment of sewage waters for the reducer component. 2) The regulatory feature of bacteria for plants (producer component) was studied in simple terrestrial systems 'wheat plants-rhizospheric microorganisms-artificial soil' where the behavior of the system varied with activity of the microbial component. For example with atmospheric carbon dioxide content elevated microbes promote intensification of photosynthesis processes, without binding the carbon in the plant biomass. 3) The indicator feature for the humans (consumer component) was studied in Life Support Systems (LSS). High sensitivity of human microflora to system conditions allowed its use as an indicator of the state of both system components and the entire ecosystem. Grant numbers: N99-04-96017, N15. c 2001. COSPAR. Published by Elsevier Science Ltd. All rights reserved.

NLM

Carbon; Closed Ecological Systems; Ecosystems; Liquid Wastes; Microbiology; Microorganisms; Plant Roots; Waste Disposal

20020022525 Alabama Univ., Huntsville, AL USA

Use of Human Modeling Simulation Software in the Task Analysis of the Environmental Control and Life Support System Component Installation Procedures

Estes, Samantha; Parker, Nelson C., Technical Monitor; [2001]; In English; Huntsville Simulation Conference, 3-4 Oct. 2001, Huntsville, AL, USA; No Copyright; Avail: Other Sources; Abstract Only

Virtual reality and simulation applications are becoming widespread in human task analysis. These programs have many benefits for the Human Factors Engineering field. Not only do creating and using virtual environments for human engineering analyses save money and time, this approach also promotes user experimentation and provides increased quality of analyses. This paper explains the human engineering task analysis performed on the Environmental Control and Life Support System (ECLSS) space station rack and its Distillation Assembly (DA) subsystem using EAI's human modeling simulation software, Jack. When installed on the International Space Station (ISS), ECLSS will provide the life and environment support needed to adequately sustain crew life. The DA is an Orbital Replaceable Unit (ORU) that provides means of wastewater (primarily urine from flight crew and experimental animals) reclamation. Jack was used to create a model of the weightless environment of the ISS Node 3, where the ECLSS is housed. Computer aided drawings of the ECLSS rack and DA system were also brought into the environment. Anthropometric models of a 95th percentile male and 5th percentile female were used to examine the human interfaces encountered during various ECLSS and DA tasks. The results of the task analyses were used in suggesting modifications to hardware and crew task procedures to improve accessibility, conserve crew time, and add convenience for the crew. This paper will address some of those suggested modifications and the method of presenting final analyses for requirements verification.

Author

Virtual Reality; Computerized Simulation; Human Factors Engineering; Environmental Control; Life Support Systems

20010057317 Arizona Univ., Tucson, AZ USA

The Effect of Doping on the Ion Conductivity and Biaxial Flexural Strength of YSZ Solid Oxide Electrolyzers

Sridhar, K. R.; Chen, Weinong; Microgravity Materials Science Conference 2000; March 2001; Volume 3, 551-555; In English; CD-ROM contains the entire Conference Proceedings presented in PDF format; No Copyright; Avail: CASI; A01, Hardcopy

Solid oxide electrolyzers generate pure oxygen from oxygen bearing gases such as carbon dioxide, water, and air. Such electrolyzers can generate oxygen from the carbon dioxide rich atmosphere of Mars, and also from the evolved gases obtained from hydrogen or carbon reduction of the lunar regolith Several studies have shown that oxygen production from Martian atmosphere as a key technology that will reduce the cost of both robotic and human missions with the added advantage of risk reduction. Space exploration missions call for developing better electrolyzer materials that offer superior thermal and mechanical characteristics as well as improved electrical performance. The electrolyte of the electrolyzer is a ceramic solid oxide such as yttria stabilized zirconia (YSZ). In order to develop structurally robust electrolyzers that would withstand the severe vibration and shock loads experienced during the launch and landing phases of the mission, it is essential to understand the damage initiation and consequent failure mechanisms and their relation to material composition and processing parameters.

Author

Performance Tests; Oxygen Production; Electrical Properties; Crack Initiation; Additives; Ion Currents

20040088114

Identification of complex flows in Taylor-Couette counter-rotating cavities

Czarny, O., Author; Serre, E., Author; Bontoux, P., Author; Lueptow, R. M., Author; Comptes rendus de l'Academie des sciences. Serie II, Mecanique, physique, chimie, sciences de l'univers, sciences de la terre; Oct 2001; ISSN 0764-4450; Volume 329, Issue 10, 727-33; In English; Copyright; Avail: Other Sources

The transition in confined rotating flows is a topical problem with many industrial and fundamental applications. The purpose of this study is to investigate the Taylor-Couette flow in a finite-length cavity with counter-rotating walls, for two aspect ratios L=5 or L=6. Two complex regimes of wavy vortex and spirals are emphasized for the first time via direct numerical simulation, by using a three-dimensional spectral method. The spatio-temporal behavior of the solutions is analyzed and compared to the few data actually available. c2001 Academie des sciences/Editions scientifiques et medicales Elsevier SAS.

NLM

Cavities; Couette Flow; Counter Rotation; Liquid Wastes; Models; Rheology; Waste Disposal; Water Treatment

20040115491

Aquatic modules for bioregenerative life support systems based on the C.E.B.A.S. biotechnology

Bluem, V., Author; Paris, F., Author; Acta astronautica; Mar-Jun 2001; ISSN 0094-5765; Volume 48, Issue 5-12, 287-97; In English; Copyright; Avail: Other Sources

Most concepts for bioregenerative life support systems are based on edible higher land plants which create some problems with growth and seed generation under space conditions. Animal protein production is mostly neglected because of the tremendous waste management problems with tetrapods under reduced weightlessness. Therefore, the 'Closed Equilibrated Biological Aquatic System' (C.E.B.A.S.) was developed which represents an artificial aquatic ecosystem containing aquatic organisms which are adapted at all to 'near weightlessness conditions' (fishes Xiphophorus helleri, water snails Biomphalaria glabrata, ammonia oxidizing bacteria and the rootless non-gravitropic edible water plant Ceratophyllum demersum). Basically the C.E.B.A.S. consists of 4 subsystems: a ZOOLOGICAL (correction of ZOOLOGICASL) COMPONENT (animal aquarium), a BOTANICAL COMPONENT (aquatic plant bioreactor), a MICROBIAL COMPONENT (bacteria filter) and an ELECTRONICAL COMPONENT (data acquisition and control unit). Superficially, the function principle appears simple: the plants convert light energy into chemical energy via photosynthesis thus producing biomass and oxygen. The animals and microorganisms use the oxygen for respiration and produce the carbon dioxide which is essential for plant photosynthesis. The ammonia ions excreted by the animals are converted by the bacteria to nitrite and then to nitrate ions which serve as a nitrogen source for the plants. Other essential ions derive from biological degradation of animal waste products and dead organic matter. The C.E.B.A.S. exists in 2 basic versions: the original C.E.B.A.S. with a volume of 150 liters and a self-sustaining standing time of more than 13 month and the so-called C.E.B.A.S. MINI MODULE with a volume of about 8.5 liters. In the latter there is no closed food loop by reasons of available space so that animal food has to be provided via an automated feeder. This device was flown already successfully on the STS-89 and STS-90 spaceshuttle missions and the working hypothesis was verified that aquatic organisms are nearly not affected at all by space conditions, i.e. that the plants exhibited biomass

production rates identical to the sound controls and that as well the reproductive, and the immune system as the embryonic and ontogenic development of the animals remained undisturbed. Currently the C.E.B.A.S. MINI MODLULE is prepared for a third spaceshuttle flight (STS-107) in spring 2001. Based on the results of the space experiments a series of prototypes of aquatic food production modules for the implementation into BLSS were developed. This paper describes the scientific disposition of the STS-107 experiment and of open and closed aquaculture systems based on another aquatic plant species, the Lemnacean Wolffia arrhiza which is cultured as a vegetable in Southeastern Asia. This plant can be grown in suspension culture and several special bioreactors were developed for this purpose. W. arrhiza reproduces mainly vegetatively by buds but also sexually from time to time and is therefore especially suitable for genetic engineering, too. Therefore it was used, in addition, to optimize the C.E.B.A.S. MINI MODULE to allow experiments with a duration of 4 month in the International Space Station the basic principle of which will be explained. In the context of aquaculture systems for BLSS the continuous replacement of removed fish biomass is an essential demand. Although fish reproduction seems not to be affected in the shortterm space experiments with the C.E.B.A.S. MINI MODULE a functional and reliable hatchery for the production of siblings under reduced weightlessness is connected with some serious problems. Therefore an automated 'reproduction module' for the herbivorous fish Tilapia rendalli was developed as a laboratory prototype. It is concluded that aquatic modules of different degrees of complexity can optimize the productivity of BLSS based on higher land plants and that they offer an unique opportunity for the production of animal protein in lunar or planetary bases.
NLM
Aquiculture; Biotechnology; Closed Ecological Systems; Life Support Systems; Marine Biology; Modules; Organisms; Weightlessness

20010088846 Institute of Space Medico-Engineering, Beijing, China
Prospect of the Advanced Life Support Program Breadboard Project at Kennedy Space Center in USA
Guo, Shuang-Sheng; Ai, Wei-Dang; Space Medicine and Medical Engineering; April 2001; ISSN 1002-0837; Volume 14, Issue No. 2, 149-153; In Chinese; Copyright; Avail: Other Sources

The Breadboard Project at Kennedy Space Center in NASA of USA was focused on the development of the bioregenerative life support components, crop plants for water, air, and food production and bioreactors for recycling of wastes. The keystone of the Breadboard Project was the Biomass Production Chamber(BPC), which was supported by 15 environmentally controlled chambers and several laboratory facilities holding a total area of 2150 sq m. In supporting the Advanced Life. Support Program(ALS Program), the Project utilizes these facilities for large-scale testing of components and development of required technologies for human-rated testbeds at Johnson Space Center in NASA, in order to enable a Lunar and a Mars mission finally.
Author
Life Support Systems; Breadboard Models; Bioreactors; Recycling; Farm Crops; Biomass

20040115488
Self-sustaining Mars colonies utilizing the North Polar Cap and the Martian atmosphere
Powell, J., Author; Maise, G., Author; Paniagua, J., Author; Acta astronautica; Mar-Jun 2001; ISSN 0094-5765; Volume 48, Issue 5-12, 737-65; In English; Copyright; Avail: Other Sources

A revolutionary new concept for the early establishment of robust, self-sustaining Martian colonies is described. The colonies would be located on the North Polar Cap of Mars and utilize readily available water ice and the CO2 Martian atmosphere as raw materials to produce all of the propellants, fuel, air, water, plastics, food, and other supplies needed by the colony. The colonists would live in thermally insulated large, comfortable habitats under the ice surface, fully shielded from cosmic rays. The habitats and supplies would be produced by a compact, lightweight (~4 metric tons) nuclear powered robotic unit termed ALPH (Atomic Liberation of Propellant and Habitat), which would land 2 years before the colonists arrived. Using a compact, lightweight 5 MW (th) nuclear reactor/steam turbine (1 MW(e)) power source and small process units (e.g., H2O electrolyzer, H2 and O2 liquefiers, methanator, plastic polymerizer, food producer, etc.) ALPH would stockpile many hundreds of tons of supplies in melt cavities under the ice, plus insulated habitats, to be in place and ready for use when the colonists landed. With the stockpiled supplies, the colonists would construct and operate rovers and flyers to explore the surface of Mars. ALPH greatly reduces the amount of Earth supplied material needed and enables large permanent colonies on Mars. It also greatly reduces human and mission risks and vastly increases the capability not only for exploration of the surrounding Martian surface, but also the ice cap itself. The North Polar Cap is at the center of the vast ancient ocean that covered much of the Martian Northern Hemisphere. Small, nuclear heated robotic probes would travel deep (1 km or more) inside the ice cap, collecting data on its internal structure, the composition and properties of the ancient Martian atmosphere, and possible

evidence of ancient life forms (microfossils, traces of DNA, etc.) that were deposited either by wind or as remnants of the ancient ocean. Details of the ALPH system, which is based on existing technology, are presented. ALPH units could be developed and demonstrated on Earth ice sheets within a few years. An Earth-Mars space transport architecture is described, in which Mars produced propellant and supplies for return journeys to Earth would be lifted with relatively low DeltaV to Mars orbit, and from there transported back to Earth orbit, enabling faster and lower cost trips from Earth to Mars. The exploration capability and quality of life in a mature Martian colony of 500 persons located on the North Polar Cap is outlined.
NLM
Closed Ecological Systems; Cold Weather; Life Support Systems; Mars (Planet); Mars Atmosphere; Mars Bases; Polar Caps

20010125132 NASA Kennedy Space Center, Cocoa Beach, FL USA
Technology Development for Human Exploration Beyond LEO in the New Millennium IAA-13-3 Strategies and Plans for Human Mars Missions
Larson, William E.; Lueck, Dale E.; Parrish, Clyde F.; Sanders, Gerald B.; Trevathan, Joseph R.; Baird, R. Scott; Simon, Tom; Peters, T.; Delgado, H., Technical Monitor; [2001]; In English; 51st International Astronautical Federation, 1-5 Oct. 2001, Toulouse, France; No Copyright; Avail: CASI; A03, Hardcopy

As we look forward into the new millennium, the extension of human presence beyond Low-Earth Orbit (LEO) looms large in the plans of NASA. The Agency's Strategic Plan specifically calls out the need to identify and develop technologies for 100 and 1000-day class missions beyond LEO. To meet the challenge of these extended duration missions, it is important that we learn how to utilize the indigenous resources available to us on extraterrestrial bodies. This concept, known as In-Situ Resource Utilization (ISRU) can greatly reduce the launch mass & cost of human missions while reducing the risk. These technologies may also pave the way for the commercial development of space. While no specific target beyond LEO is identified in NASA's Strategic Plan, mission architecture studies have been on-going for the Moon, Mars, Near-Earth Asteroids and Earth/Moon & Earth/Sun Libration Points. As a result of these studies, the NASA Office of Space Flight (Code M) through the Johnson and Kennedy Space Centers, is leading the effort to develop ISRU technologies and systems to meet the current and future needs of human missions beyond LEO and on to Mars. This effort also receives support from the NASA Office of Biological and Physical Research (Code U), the Office of Space Science (Code S), and the Office of Aerospace Technology (Code R). This paper will present unique developments in the area of fuel and oxidizer production, breathing air production, water production, C02 collection, separation of atmospheric gases, and gas liquefaction and storage. A technology overview will be provided for each topic along with the results achieved to date, future development plans, and the mission architectures that these technologies support.
Author
Long Duration Space Flight; In Situ Resource Utilization; Materials Recovery

20040118211
Main characteristics of biological components of developing life support system observed during the experiments aboard orbital complex MIR
Sychev, V. N., Author; Shepelev, E. Y., Author; Meleshko, G. I., Author; Gurieva, T. S., Author; Levinskikh, M. A., Author; Podolsky, I. G., Author; Dadasheva, O. A., Author; Popov, V. V., Author; Advances in space research : the official journal of the Committee on Space Research (COSPAR); 2001; Volume 27, Issue 9, 1529-34; In English; Copyright; Avail: Other Sources

Since 1990, the orbital complex MIR has witnessed several incubator experiments for determination of spaceflight effects on embryogenesis of Japanese quail. First viable chicks who had completed the whole embryological cycle in MIR microgravity hatched out in 1990; it became clear that newborns would not be able to adapt to microgravity unaided. There were 8 successful incubations of chicks in the period from 1990 to 1999. In 1995-1997 the MIR-NASA space science program united Russian and US investigators. As a result, experiments Greenhouse-1 and 2 were performed with an effort to grow super dwarf wheat from seed to seed, and experiment Greenhouse-3 aimed at receiving two successive generations of Brassica rapa. But results of these experiments could not be used for definitive conclusions concerning effects of spaceflight on plant ontogenesis and, therefore, experiments Greenhouse-4 and 5 were staged within the framework of the Russian national space program. The experiments finally yielded wheat seeds. Some of the seeds was left on the space station and, being planted, gave viable seedlings which, in their turn, produced the second crop of space seeds.
NLM
Birds; Embryology; Embryos; Life Sciences; Life Support Systems; Plants (Botany); Weightlessness

20020023733 NASA Marshall Space Flight Center, Huntsville, AL USA

Compatibility Testing of Non-Metallic Materials for the Urine Processor Assembly (UPA) of International Space Station (ISS)

Wingard, Charles Doug; Munafo, Paul M., Technical Monitor; [2001]; In English; North American Thermal Analysis Society Conference, 24-26 Sep. 2001, Saint Louis, MO, USA; No Copyright; Avail: Other Sources; Abstract Only

In the International Space Station (ISS), astronauts will convert urine into potable water with the Urine Processor Assembly (UPA). The urine is distilled, with the concentrated form containing about 15% brine solids, and the dilute form as a blend of pre-treated urine/wastewater. Eighteen candidate non-metallic materials for use with the UPA were tested in 2000 for compatibility with the concentrated and dilute urine solutions for continuous times of at least 30 days, and at conditions of 0.5 psia pressure and 100 F, to simulate the working UPA environment. A primary screening test for each material (virgin and conditioned) was dynamic mechanical analysis (DMA) in the stress relaxation mode, with the test data used to predict material performance for a 10-year use in space. Data showed that most of the candidate materials passed the compatibility testing, although a few significant changes in stress relaxation modulus were observed.

Author

Water Reclamation; International Space Station; Urine; Potable Water

20010097723 NASA Ames Research Center, Moffett Field, CA USA

Advanced Life Support Research and Technology Development

Kliss, Mark; [2001]; In English, 12-16 May 2001, Guelph, Ontario, Canada

Contract(s)/Grant(s): RTOP 131-20-10; No Copyright; Avail: CASI; A03, Hardcopy

A videograph outlining life support research. The Human Exploration and Development of Space (HEDS) Enterprise's goals are to provide life support self-sufficiency for human beings to carry out research and exploration productively in space, to open the door for planetary exploration, and for benefits on Earth. Topics presented include the role of NASA Ames, funding, and technical monitoring. The focused research areas discussed include air regeneration, carbon dioxide removal, Mars Life Support, water recovery, Vapor Phase Catalytic Ammonia Removal (VPCAR), solid waste treatment, and Supercritical Water Oxidation (SCWC). Focus is placed on the utilization of Systems Integration, Modeling and Analysis (SIMA) and Dynamic Systems Modeling in this research.

CASI

Life Support Systems; Research and Development; Air Conditioning; Water Reclamation; Waste Treatment

20010106935 Tsinghua Univ., Bejing, China

Mass Optimization of Thermal Network Model of Coupled Dual-Loop Thermal Control System in Spacecraft

Zhang, Xin-Rong; Ren, Jian-Xun; Xu, Xiang-Hua; Liang, Xin-Gang; Space Medicine and Medical Engineering; August 2001; ISSN 1002-0837; Volume 14, Issue No. 4, 277-281; In Chinese; Copyright; Avail: Other Sources

The objective of this research was to deal with the mass optimization of thermal control system as well as environmental control and life support system (ECLSS) of manned spacecraft. The thermo-hydraulic network composed of coupled liquid dual-loop and gas loops was studied. Physical and mathematical models were established and used for flow, heat transfer and mass calculation in the network. The influences of various operational and structural parameters on the mass were analyzed. There were optimal pipe diameters for internal loop and external loop; there existed an upper limit of flow rate in the internal loop and lower limit in the external loop; there were also optimal flow rates in the loops and optimal exit temperature of the radiator. Reasonable design of these parameters were very important for reducing the system mass.

Author

Manned Spacecraft; Spacecraft Environments; Temperature Control; Life Support Systems; Environmental Control; Loops; Design Optimization; Structural Design

20040088807

Preliminary development and evaluation of an algae-based air regeneration system

Nienow, J. A., Author; Life support & biosphere science : international journal of earth space; 2000; ISSN 1069-9422; Volume 7, Issue 2, 203-7; In English

Contract(s)/Grant(s): NAGW-4897; Copyright; Avail: Other Sources

The potential of air regeneration system based on the growth of microalgae on the surface of porous ceramic tubes is evaluated. The algae have been maintained in the system for extended periods, up to 360 days. Preliminary measurements of the photosynthetic capacity have been made for Chlorella vulgaris (UTEX 259), Neospongiococcum punctatum (UTEX 786),

Stichococcus sp., and Gloeocapsa sp. Under standard test conditions (photosynthetic photon flux approximately 66 micromoles m-2 s-1, initial CO2 concentration approximately 450 micromoles mol-1), mature tubes remove up to 0.2 micromoles of CO2 per tube per minute. The rate of removal increases with photon flux up to at least 225 micromoles m-2 s-1 (PPF); peak rates of 0.35 micromoles of CO2 per tube per minute have been achieved with Chlorella vulgaris. These rates correspond to between 120 and 210 micromoles of CO2 removed per square meter of projected area per minute.
NLM
Air Conditioning; Algae; Bacteria; Blue Green Algae; Carbon Dioxide; Metabolism; Regeneration (Engineering)

20040107145
Performance of a water suction system using hydrophilic fibrous cloth under low gravity and microgravity in parabolic flight
Tani, A., Author; Saito, T., Author; Kitaya, Y., Author; Takahashi, H., Author; Goto, E., Author; Seibutsu kankyo chosetsu. [Environment control in biology; Jun 2000; ISSN 0582-4087; Volume 38, Issue 2, 89-97; In English; Copyright; Avail: Other Sources

For suction of water from a water supply vessel including both water and air under microgravity and g-jitter conditions, a water suction system using hydrophilic fibrous cloth was developed and its performance was evaluated at 0.01-0.02 g-realized for 20 s by parabolic flight in an aircraft. Vessels used for the experiment were glass flasks and had a suction port for suction filtration. A piece of hydrophilic fibrous cloth was arranged along the inner surface of the vessels and the end was fixed to the suction port of the vessels. In vessel without hydrophilic cloths and containing 220 mL of water, the water did not move more than 5 mm along the inner surface and did not reach the suction port under low gravity. When hydrophilic cloths were used, on the other hand, water gathered onto the cloth surface, moved up along the cloth and reached the suction port under low gravity. The amount of water sucked from vessels varied with the amount of water in the vessel and the sectional area of hydrophilic cloths. When the vessels including both water and air were flown during parabolic flight (10(-4) g), water in the vessel moved along the cloth and a water film was formed on the cloth. These results indicated that it is possible to suck water using the fibrous cloth suction system under low gravity and microgravity conditions. Under low gravity conditions, it was difficult to suck water only. However, it is not necessary to separate water from air when the system is used for supplying water to plant root medium consisting of both liquid and gas phases.
NLM
Fabrics; Life Support Systems; Microgravity; Parabolic Flight; Suction; Water; Weightlessness

20040088689
Ozonation and alkaline-peroxide pretreatment of wheat straw for Cryptococcus curvatus fermentation
Greenwalt, C. J., Author; Hunter, J. B., Author; Lin, S., Author; McKenzie, S., Author; Denvir, A., Author; Life support & biosphere science : international journal of earth space; 2000; ISSN 1069-9422; Volume 7, Issue 3, 243-9; In English; Copyright; Avail: Other Sources

Crop residues in an Advanced Life Support System (ALS) contain many valuable components that could be recovered and used. Wheat is 60% inedible, with approximately 90% of the total sugars in the residue cellulose and hemicellulose. To release these sugars requires pretreatment followed by enzymatic hydrolysis. Cryptococcus curvatus, an oleaginous yeast, uses the sugars in cellulose and hemicellulose for growth and production of storage triglycerides. In this investigation, alkaline-peroxide and ozonation pretreatment methods were compared for their efficiency to release glucose and xylose to be used in the cultivation of C. curvatus. Leaching the biomass with water at 65 degrees C for 4 h prior to pretreatment facilitated saccharification. Alkaline-peroxide and ozone pretreatment were almost 100% and 80% saccharification efficient, respectively. The sugars derived from the hydrolysis of alkaline-peroxide-treated wheat straw supported the growth of C. curvatus and the production of edible single-cell oil.
NLM
Closed Ecological Systems; Fermentation; Fungi; Ozone; Peroxides; Pretreatment; Wheat

20040119890
A hierarchical approach to the sustainable management of controlled ecological life support systems: part 2, systems realization and analysis
Pawlowski, C. W., Author; Auslander, D. M., Author; Life support & biosphere science : international journal of earth space; 2000; ISSN 1069-9422; Volume 7, Issue 2, 171-85; In English; Copyright; Avail: Other Sources

The second in a series of two articles exploring the sustainable management of a controlled ecological life support system

(CELSS), this article examines the feasibility of the approach outlined in Part 1 using a simple, abstract CELSS representation comprising buffers and pumps. We develop a two-level management hierarchy in which the top level imposes constraints on the operation of the lower level. The compartments can operate freely within these constraints. This freedom can be used to enhance system performance and robustness. Additionally, the higher level does not require detailed subsystem representations. Our approach to sustainable management of CELSS allows for the active distribution of system mass, taking into account component constraints and system dynamics.
NLM
Algorithms; Closed Ecological Systems; Life Support Systems; Models; Support Systems; Systems Analysis

20040120018

Integration test project of CEEF--a test bed for Closed Ecological Life Support Systems

Nitta, K., Author; Otsubo, K., Author; Ashida, A., Author; Advances in space research : the official journal of the Committee on Space Research (COSPAR); 2000; Volume 26, Issue 2, 335-8; In English; Copyright; Avail: Other Sources

CEEF (Closed Ecology Experiment Facilities) were installed at Rokkasho village in northern Japan, for the purpose of clarifying life-support mechanisms in a completely closed space, such as a Lunar or Mars base. An integration test using the Closed Plantation Experiment Facility and Closed Animal Breeding & Habitation Experiment Facility is needed before conducting an entire closed experiment including plants, animals and humans. These integration tests are planned to be conducted step by step from fiscal 2001 to 2008.
NLM
Air Conditioning; Architecture; Closed Ecological Systems; Life Support Systems; Systems Integration; Test Stands

20040088915

Life sciences: space life support systems and the lunar farside crater Saha proposal. Proceedings of the F4.4, F4.5 and F3.7 Symposia of COSPAR Scientific Commission F which were held during the Thirty-second COSPAR Scientific Assemby, Nagoya, Japan, July, 1998

Tibbitts, T. W., Principal Investigator; Advances in space research : the official journal of the Committee on Space Research (COSPAR); 2000; Volume 26, Issue 2, 243-377; In English; Copyright; Avail: Other Sources

No abstract available
Aerospace Systems; Astronomy; Closed Ecological Systems; Conferences; Japan; Life Support Systems; Lunar Craters; Moon; Weightlessness

20040088619

High relative humidity increases yield, harvest index, flowering, and gynophore growth of hydroponically grown peanut plants

Mortley, D. G., Author; Bonsi, C. K., Author; Loretan, P. A., Author; Hill, W. A., Author; Morris, C. E., Author; HortScience : a publication of the American Society for Horticultural Science; Feb 2000; ISSN 0018-5345; Volume 35, Issue 1, 46-8; In English
Contract(s)/Grant(s): NAG10-0024; Copyright; Avail: Other Sources

Growth chamber experiments were conducted to study the physiological and growth response of peanut (Arachis hypogaea L.) to 50% and 85% relative humidity (RH). The objective was to determine the effects of RH on pod and seed yield, harvest index, and flowering of peanut grown by the nutrient film technique (NFT). ‘Georgia Red’ peanut plants (14 days old) were planted into growth channels (0.15 x 0.15 x 1.2 m). Plants were spaced 25 cm apart with 15 cm between channels. A modified half-Hoagland solution with an additional 2 mM Ca was used. Solution pH was maintained between 6.4 and 6.7, and electrical conductivity (EC) ranged between 1100 and 1200 microS cm-1. Temperature regimes of 28/22 degrees C were maintained during the light/dark periods (12 hours each) with photosynthetic photon flux (PPF) at canopy level of 500 micromoles-m-2s-1. Foliage and pod fresh and dry weights, total seed yield, harvest index (HI), and seed maturity were greater at high than at low RH. Plants grown at 85% RH had greater total and individual leaflet area and stomatal conductance, flowered 3 days earlier and had a greater number of flowers reaching anthesis. Gynophores grew more rapidly at 85% than at 50% RH.
NLM
Closed Ecological Systems; Humidity; Hydroponics; Leguminous Plants

20040088618

Growth, pod, and seed yield, and gas exchange of hydroponically grown peanut in response to CO2 enrichment

Stanciel, K., Author; Mortley, D. G., Author; Hileman, D. R., Author; Loretan, P. A., Author; Bonsi, C. K., Author; Hill, W. A., Author; HortScience : a publication of the American Society for Horticultural Science; Feb 2000; ISSN 0018-5345; Volume 35, Issue 1, 49-52; In English

Contract(s)/Grant(s): NAG10-0024; Copyright; Avail: Other Sources

The effects of elevated CO2 on growth, pod, and seed yield, and gas exchange of 'Georgia Red' peanut (Arachis hypogaea L.) were evaluated under controlled environmental conditions. Plants were exposed to concentrations of 400 (ambient), 800, and 1200 micromoles mol-1 CO2 in reach-in growth chambers. Foliage fresh and dry weights increased with increased CO2 up to 800 micromoles mol-1, but declined at 1200 micromoles mol-1. The number and the fresh and dry weights of pods also increased with increasing CO2 concentration. However, the yield of immature pods was not significantly influenced by increased CO2. Total seed yield increased 33% from ambient to 800 micromoles mol-1 CO2, and 4% from 800 to 1200 micromoles mol-1 CO2. Harvest index increased with increasing CO2. Branch length increased while specific leaf area decreased linearly as CO2 increased from ambient to 1200 micromoles mol-1. Net photosynthetic rate was highest among plants grown at 800 micromoles mol-1. Stomatal conductance decreased with increased CO2. Carboxylation efficiency was similar among plants grown at 400 and 800 micromoles mol-1 and decreased at 1200 micromoles mol-1 CO2. These results suggest that CO2 enrichment from 400 to 800 micromoles mol-1 had positive effects on peanut growth and yield, but above 800 micromoles mol-1 enrichment seed yield increased only marginally.

NLM

Carbon Dioxide; Closed Ecological Systems; Enrichment; Gas Exchange; Hydroponics; Leguminous Plants; Pods (External Stores); Seeds

20040119990

4th International Conference on Life Support and Biosphere Science: Baltimore Mariott Inner Harbor, Baltimore, Maryland, August 6-9, 2000

Life support & biosphere science : international journal of earth space; 2000; ISSN 1069-9422; Volume 7, Issue 1, 1-148; In English; Copyright; Avail: Other Sources

No abstract available

Biosphere; Closed Ecological Systems; Conferences; Harbors; Life Support Systems; Plants (Botany)

20040119960

Physical-chemical treatment of wastes: a way to close turnover of elements in LSS

Gribovskaya, I. V., Author; Zolotukhin, I. G., Author; Acta astronautica; May 2000; ISSN 0094-5765; Volume 46, Issue 9, 585-9; In English; Copyright; Avail: Other Sources

'Man-plants-physical-chemical unit' system designed for space stations or terrestrial ecohabitats to close steady-state mineral, water and gas exchange is proposed. The physical-chemical unit is to mineralize all inedible plant wastes and physiological human wastes (feces, urine, gray water) by electromagnetically activated hydrogen peroxide in an oxidation reactor. The final product is a mineralized solution containing all elements balanced for plants' requirements. The solution has been successfully used in experiments to grow wheat, beans and radish. The solution was reusable: the evaporated moisture was replenished by the phytotron condensate. Sodium salination of plants was precluded by evaporating reactor-mineralized urine to sodium saturation concentration to crystallize out NaCl which can be used as food for the crew. The remaining mineralized product was brought back for nutrition of plants. The gas composition of the reactor comprises O2, N2, CO2, NH3, H2. At the reactor's output hydrogen and oxygen were catalyzed into water, NH3 was converted in a water trap into NH4 and used for nutrition of plants. A special accessory at the reactor's output may produce hydrogen peroxide from intrasystem water and gas which makes possible to close gas loops between LSS components.

NLM

Closed Ecological Systems; Leguminous Plants; Life Support Systems; Minerals; Plants (Botany); Waste Management; Wheat

20040103340

[Application of nitrifying and denitrifying processes to waste management of aquatic life support in space]

Shimura, R., Author; Kumagai, H., Author; Kozu, H., Author; Motoki, S., Author; Ijiri, K., Author; Nagaoka, S., Author; Uchu seibutsu kagaku; Oct 2000; ISSN 0914-9201; Volume 14, Issue 3, 138-9; In Japanese; Copyright; Avail: Other Sources

No abstract available

Denitrogenation; Life Support Systems; Marine Biology; Nitrogen; Organisms; Waste Management; Weightlessness

20040117990

Long-duration space mission regenerative life support

Samsonov, N. M., Author; Bobe, L. S., Author; Gavrilov, L. I., Author; Novikov, V. M., Author; Farafonov, N. S., Author; Grigoriev, J. I., Author; Zaitsev, E. N., Author; Romanov, S. J., Author; Grogoriev, A. I., Author; Sinjak, J. E., Author; Acta astronautica; Jul-Nov 2000; ISSN 0094-5765; Volume 47, Issue 2-9, 129-38; In English; Copyright; Avail: Other Sources

The paper deals with the construction of physical/chemical life support systems of orbiting space station Mir and the Russian segment of the international space station (ISS). Based on experience gained in development and long-term operation of systems for water recovery and air revitalization balance and energy/mass characteristics of promising life support systems (LSS) are analyzed. Physical/chemical life support systems with regenerative systems updated as a result of the operation on the ISS may be used at an initial phase of manned interplanetary missions. c 2000 International Astronautical Federation. Published by Elsevier Science Ltd. All rights reserved.

NLM

Closed Ecological Systems; Life Support Systems; Long Duration Space Flight; Weightlessness

20040119889

Methodology of biospherics for theoretical sciences and practical use

Pechurkin, N. S., Author; Maryasova, T., Author; Life support & biosphere science : international journal of earth space; 2000; ISSN 1069-9422; Volume 7, Issue 2, 219-24; In English

Contract(s)/Grant(s): 6F0-114; 94-3279; Copyright; Avail: Other Sources

This article deals with some methodological aspects of biospherics connected with theoretical sciences development and prospective use for practical application. Properties of experimental objects, methods and goals of biospherics as synthesising science have been discussed. The problem of stability of incomplete (natural and artificial) ecosystems has been considered. The concept of the ecosystem health based on effective functioning of different types of ecosystems has been developed.

NLM

Closed Ecological Systems; Ecosystems; Models

20040106689

Effects of side cooling on temperature, humidity and water recycling efficiency in a culture vessel for a space experiment--results of ground experiment

Tani, A., Author; Seino, K., Author; Seibutsu kankyo chosetsu. [Environment control in biology; Jun 2000; ISSN 0582-4087; Volume 38, Issue 2, 79-87; In English; Copyright; Avail: Other Sources

Seed-to-seed experiments using dwarf plants will be conducted in Cell Biology Experiment Facility (CBEF) set up in the International Space Station (ISS). Development of a simple system to recycle water transpired by plants is necessary to save space and electrical power. A cooling system using a cooling plate that cools one side of the ventilated culture vessel to enhance water vapor condensation was developed. Effects of side cooling on air temperature, relative humidity and water recycling efficiency in the culture vessel were investigated on the ground. Decreasing the cooling plate temperature lowered temperatures of cooled side and inside air. Cooling treatment also decreased relative humidity inside the vessel less than 90% and lowered the amount of water vapor lost from the vessel through ventilation filters. This seemed to be due to the increased water vapor condensation onto the cooled side. To investigate the effect of increases in outside humidity on water recycling efficiency in the culture vessel, a water vapor transfer model was established. The calculation results indicate that an increase in relative humidity around the vessel can decrease water vapor loss from the vessel, increase water condensation onto the cooled side, and therefore, enhance water recycling efficiency in the vessel. The side cooling system seems to be useful for the CBEF in ISS because relative humidity in the CBEF is controllable.

NLM

Closed Ecological Systems; Cooling; Humidity; Life Support Systems; Recycling; Spaceborne Experiments; Temperature; Temperature Effects; Water

20040088659

Microgravity effects on water supply and substrate properties in porous matrix root support systems

Bingham, G. E., Author; Jones, S. B., Author; Or, D., Author; Podolski, I. G., Author; Levinskikh, M. A., Author; Sytchov, V. N., Author; Ivanova, T., Author; Kostov, P., Author; Sapunova, S., Author; Dandolov, I., Author; Bubenheim, D. B., Author; Jahns, G., Author; Campbell, W. F., Principal Investigator; Acta astronautica; Dec 2000; ISSN 0094-5765; Volume 47, Issue 11, 839-48; In English; Copyright; Avail: Other Sources

The control of water content and water movement in granular substrate-based plant root systems in microgravity is a complex problem. Improper water and oxygen delivery to plant roots has delayed studies of the effects of microgravity on plant development and the use of plants in physical and mental life support systems. Our international effort (USA, Russia and Bulgaria) has upgraded the plant growth facilities on the Mir Orbital Station (OS) and used them to study the full life cycle of plants. The Bulgarian-Russian-developed Svet Space Greenhouse (SG) system was upgraded on the Mir OS in 1996. The US developed Gas Exchange Measurement System (GEMS) greatly extends the range of environmental parameters monitored. The Svet-GEMS complex was used to grow a fully developed wheat crop during 1996. The growth rate and development of these plants compared well with earth grown plants indicating that the root zone water and oxygen stresses that have limited plant development in previous long-duration experiments have been overcome. However, management of the root environment during this experiment involved several significant changes in control settings as the relationship between the water delivery system, water status sensors, and the substrate changed during the growth cycles. c 2001 Published by Elsevier Science Ltd. All rights reserved.
NLM
Culture Media; Microgravity; Plant Roots; Porosity; Substrates; Support Systems; Water; Weightlessness; Wheat

20040077121 NASA Ames Research Center, Moffett Field, CA, USA
Development of the Vapor Phase Catalytic Ammonia Removal Process
Flynn, Michael; Borchers, Bruce; Research and Technology 1999; December 2000, 155-156; In English; No Copyright; Avail: CASI; A01, Hardcopy

Ames Research Center (ARC) has recently completed the development and testing of a prototype Vapor Phase Catalytic Ammonia Removal (VPCAR) system that represents the next generation in spaceflight water recovery systems. Water is the single largest resupply requirement associated with human spaceflight, accounting for 87% by mass of an astronaut s daily metabolic requirement. The VPCAR system achieves a mass metric almost an order of magnitude better than the current state-of-the-art water processors. (Mass metric is a technique used to reduce all performance parameters into launch mass.) Incorporating the VPCAR technology into human spaceflight missions could potentially save hundreds of millions of dollars in resupply costs, depending on the specific mission scenario. As a result, a human-rated version of the VPCAR technology has been authorized for development, and when completed it will be used for human testing in a closed chamber. The VPCAR process is a two-step distillation-based water processor. The current configuration of the technology is shown. The VPCAR process is characterized by the use of a wiped-film rotating-disk vacuum evaporator to volatilize water, small molecular weight organics, and ammonia. This vapor stream is then oxidized in a vapor phase catalytic reactor to destroy any contaminants. The VPCAR process uses two catalytic beds to oxidize contaminants and decompose any nitrous oxide (N2O) produced in the first bed. The first catalytic bed oxidizes organics to carbon dioxide (CO2) and water, and ammonia to N2O and water. This oxidation reactor contains 1% platinum on alumina pellets and operates at about 523 kelvin (K). The second catalytic bed reduces the N2O to nitrogen and oxygen. This reduction catalyst contains 0.5% ruthenium on alumina pellets and operates at about 723 K. The reactor and distillation functions occur in a single modular process step, no scheduled maintenance is required, and the system has no resupply requirements. The process achieves between 97 and 98% water recovery. The VPCAR activity is significant because it represents the development of the next generation of life support water recovery technology. It also shows how the research and development capabilities of one NASA center can be integrated into the operational requirements of another NASA center to reduce the cost of human spaceflight programs. Ames has been involved from the first principle definition to the model development, bench-scale and lab-scale prototype development, and contract management of the development of a human-rated version of the technology for transfer to a NASA spaceflight center. Johnson Space Center will develop the final spaceflight version.
Derived from text
Ammonia; Catalysts; Prototypes; Vapor Phases; Systems Engineering; Water Reclamation

20010076879 Shimizu Corp., Japan
Study on the Utilization of Lunar Resources
Kanamori, Hiroshi; Proceedings of Advanced Space Technology Workshop; September 2000, 269-271; In English; Also available within the Conference Proceedings with 4 other reports on CD-ROM. See 20010068892.; Copyright; Avail: CASI; A01, Hardcopy; US Distribution and Sales Only

This conference paper outlines resource utilization technology and the kind of technology that will be necessary in the future. The starting point is data on the lunar environment and resources obtained by the Apollo project. Based on this data, there have been many plans to produce a variety of materials from lunar resources. The approaches used in such studies basically fall into two groups. The first generally entails finding out how to use these resources in future space development

scenario. For example, there is a study on what economic effects the oxygen and helium-3 on the Moon will have on future space development. The other approach is technical, and focuses on how to actually make these materials from the resources available.
Derived from text
Lunar Resources; Lunar Bases; Lunar Environment

20010076246 NASA Ames Research Center, Moffett Field, CA USA
Modeling Separate and Combined Atmospheres in BIO-Plex
Jones, Harry; Finn, Cory; Kwauk, Xian-Min; Blackwell, Charles; Luna, Bernadette, Technical Monitor; [2000]; In English; International Conference on Environmental Systems, 9-12 Jul. 2001, Orlando, FL, USA
Contract(s)/Grant(s): RTOP 131-20-10; No Copyright; Avail: Other Sources; Abstract Only

We modeled BIO-Plex designs with separate or combined atmospheres and then simulated controlling the atmosphere composition. The BIO-Plex is the Bioregenerative Planetary Life Support Systems Test Complex, a large regenerative life support test facility under development at NASA Johnson Space Center. Although plants grow better at above-normal carbon dioxide levels, humans can tolerate even higher carbon dioxide levels. incinerator exhaust has very high levels of carbon dioxide. An elaborate BIO-Plex design would maintain different atmospheres in the crew and plant chambers and isolate the incinerator exhaust in the airlock. This design easily controls the crew and plant carbon dioxide levels but it uses many gas processors, buffers, and controllers. If all the crew's food is grown inside BIO-Plex, all the carbon dioxide required by the plants is supplied by crew respiration and the incineration of plant and food waste. Because the oxygen mass flow must balance in a closed loop, the plants supply all the oxygen required by the crew and the incinerator. Using plants for air revitalization allows using fewer gas processors, buffers, and controllers. In the simplest design, a single combined atmosphere was used for the crew, the plant chamber, and the incinerator. All gas processors, buffers, and controllers were eliminated. The carbon dioxide levels were necessarily similar for the crew and plants. If most of the food is grown, carbon dioxide can be controlled at the desired level by scheduling incineration. An intermediate design uses one atmosphere for the crew and incinerator chambers and a second for the plant chamber. This allows different carbon dioxide levels for the crew and plants. Better control of the atmosphere is obtained by varying the incineration rate. Less gas processing, storage, and control is needed if more food is grown.
Author
Atmospheric Composition; Life Support Systems; Mathematical Models; Closed Ecological Systems; Plants (Botany)

20040088816
Wheat response to differences in water and nutritional status between zeoponic and hydroponic growth systems
Steinberg, S. L., Author; Ming, D. W., Author; Henderson, K. E., Author; Carrier, C., Author; Gruener, J. E., Author; Barta, D. J., Author; Henninger, D. L., Author; Agronomy journal; Mar-Apr 2000; ISSN 0002-1962; Volume 92, Issue 2, 353-60; In English; Copyright; Avail: Other Sources

Hydroponic culture has traditionally been used for controlled environment life support systems (CELSS) because the optimal environment for roots supports high growth rates. Recent developments in zeoponic substrate and microporous tube irrigation (ZPT) also offer high control of the root environment. This study compared the effect of differences in water and nutrient status of ZPT or hydroponic culture on growth and yield of wheat (Triticum aestivum L. cv. USU-Apogee). In a side-by-side test in a controlled environment, wheat was grown in ZPT and recirculating hydroponics to maturity. Water use by plants grown in both culture systems peaked at 15 to 20 L m-2 d-1 up to Day 40, after which it declined more rapidly for plants grown in ZPT culture due to earlier senescence of leaves. No consistent differences in water status were noted between plants grown in the two culture systems. Although yield was similar, harvest index was 28% lower for plants grown in ZPT than in hydroponic culture. Sterile green tillers made up 12 and 0% of the biomass of plants grown in ZPT and hydroponic culture, respectively. Differences in biomass partitioning were attributed primarily to NH4-N nutrition of plants grown in ZPT compared with NO3-N in hydroponic nutrient solution. It is probable that NH4-N-induced Ca deficiency produced excess tillering and lower harvest index for plants grown in ZPT culture. These results suggest that further refinements in zeoponic substrate would make ZPT culture a viable alternative for achieving high productivity in a CELSS.
NLM
Culture Media; Hydroponics; Metabolism; Water; Wheat; Zeolites

20010068380 Florida Inst. of Tech., Melbourne, FL USA

Modeling and Analysis of the Reverse Water Gas Shift Process for In-Situ Propellant Production

Whitlow, Jonathan E.; 1999 Research Reports: NASA/ASEE Summer Faculty Fellowship Program; November 2000, 197-206; In English; No Copyright; Avail: CASI; A02, Hardcopy

This report focuses on the development of mathematical models and simulation tools developed for the Reverse Water Gas Shift (RWGS) process. This process is a candidate technology for oxygen production on Mars under the In-Situ Propellant Production (ISPP) project. An analysis of the RWGS process was performed using a material balance for the system. The material balance is very complex due to the downstream separations and subsequent recycle inherent with the process. A numerical simulation was developed for the RWGS process to provide a tool for analysis and optimization of experimental hardware, which will be constructed later this year at Kennedy Space Center (KSC). Attempts to solve the material balance for the system, which can be defined by 27 nonlinear equations, initially failed. A convergence scheme was developed which led to successful solution of the material balance, however the simplified equations used for the gas separation membrane were found insufficient. Additional more rigorous models were successfully developed and solved for the membrane separation. Sample results from these models are included in this report, with recommendations for experimental work needed for model validation.

Author

Material Balance; Software Development Tools

20040088806

Pythium invasion of plant-based life support systems: biological control and sources

Jenkins, D. G., Author; Cook, K. L., Author; Garland, J. L., Author; Board, K. F., Author; Sager, J. C., Principal Investigator; Life support & biosphere science : international journal of earth space; 2000; ISSN 1069-9422; Volume 7, Issue 2, 209-18; In English; Copyright; Avail: Other Sources

Invasion of plant-based life support systems by plant pathogens could cause plant disease and disruption of life support capability. Root rot caused by the fungus, Pythium, was observed during tests of prototype plant growth systems containing wheat at the Kennedy Space Center (KSC). We conducted experiments to determine if the presence of complex microbial communities in the plant root zone (rhizosphere) resisted invasion by the Pythium species isolated from the wheat root. Rhizosphere inocula of different complexity (as assayed by community-level physiological profile: CLPP) were developed using a dilution/extinction approach, followed by growth in hydroponic rhizosphere. Pythium growth on wheat roots and concomitant decreases in plant growth were inversely related to the complexity of the inocula during 20-day experiments in static hydroponic systems. Pythium was found on the seeds of several different wheat cultivars used in controlled environmental studies, but it is unclear if the seed-borne fungal strain(s) were identical to the pathogenic strain recovered from the KSC studies. Attempts to control pathogens and their effects in hydroponic life support systems should include early inoculation with complex microbial communities, which is consistent with ecological theory.

NLM

Algae; Closed Ecological Systems; Hydroponics; Life Support Systems; Microbiology; Wheat

20040119891

A hierarchical approach to the sustainable management of Controlled Ecological Life Support Systems: part 1, an ecological and engineering synthesis

Pawlowski, C. W., Author; Auslander, D. M., Author; Life support & biosphere science : international journal of earth space; 2000; ISSN 1069-9422; Volume 7, Issue 2, 161-70; In English; Copyright; Avail: Other Sources

In this article we present, in an expository manner, an approach to the sustainable management of a Controlled Ecological Life Support System (CELSS) based on concepts from both engineering and ecology. Our perspective leads us to express the sustainability of CELSS in terms of constraints imposed on its subsystems. These constraints are of two types: static and operational. Static constraints capture the basic sustainability requirements of the individual subsystem components--they represent the absolute limits (bounds) on the operating range of these subsystems. Operational constraints, on the other hand, represent a response to global changes in the availability of system resources. They are imposed as the system evolves dynamically to avert shortages or surpluses in resources in various subsystems. As well as having implications on design, our perspective, termed the constraint perspective, leads naturally to a management hierarchy. The second article (this issue) in this series will explore the feasibility of this approach and demonstrate some of its consequences based on a simple CELSS model.

NLM

Closed Ecological Systems; Ecology; Life Support Systems; Systems Integration

20040088737

Low potassium enhances sodium uptake in red-beet under moderate saline conditions

Subbarao, G. V., Author; Wheeler, R. M., Author; Stutte, G. W., Author; Levine, L. H., Author; Sager, J. C., Principal Investigator; Journal of plant nutrition; 2000; ISSN 0190-4167; Volume 23, Issue 10, 1449-70; In English; Copyright; Avail: Other Sources

Due to the discrepancy in metabolic sodium (Na) requirements between plants and animals, cycling of Na between humans and plants is limited and critical to the proper functioning of bio-regenerative life support systems, being considered for long-term human habitats in space (e.g., Martian bases). This study was conducted to determine the effects of limited potassium (K) on growth, Na uptake, photosynthesis, ionic partitioning, and water relations of red-beet (Beta vulgaris L. ssp. vulgaris) under moderate Na-saline conditions. Two cultivars, Klein Bol, and Ruby Queen were grown for 42 days in a growth chamber using a re-circulating nutrient film technique where the supplied K levels were 5.0, 1.25, 0.25, and 0.10 mM in a modified half-strength Hoagland solution salinized with 50 mM NaCl. Reducing K levels from 5.0 to 0.10 mM quadrupled the Na uptake, and lamina Na levels reached -20 g kg-1 dwt. Lamina K levels decreased from -60 g kg-1 dwt at 5.0 mM K to -4.0 g kg-1 dwt at 0.10 mM K. Ruby Queen and Klein Bol responded differently to these changes in Na and K status. Klein Bol showed a linear decline in dry matter production with a decrease in available K, whereas for cv. Ruby Queen, growth was stimulated at 1.25 mM K and relatively insensitive to a further decreases of K down to 0.10 mM. Leaf glycinebetaine levels showed no significant response to the changing K treatments. Leaf relative water content and osmotic potential were significantly higher for both cultivars at low-K treatments. Leaf chlorophyll levels were significantly decreased at low-K treatments, but leaf photosynthetic rates showed no significant difference. No substantial changes were observed in the total cation concentration of plant tissues despite major shifts in the relative Na and K uptake at various K levels. Sodium accounted for 90% of the total cation uptake at the low K levels, and thus Na was likely replacing K in osmotic functions without negatively affecting the plant water status, or growth. Our results also suggest that cv. Ruby Queen can tolerate a much higher Na tissue concentration than cv. Klein Bol before there is any growth reduction. Grant numbers: 12180.

NLM

Genetics; Leaves; Plants (Botany); Potassium; Sodium

20040107670

[The equipment of using Azolla for O2-supplementation (correction of supplimentation) and its test]

Chen, M., Author; Liu, X. S., Author; Liu, Z. C., Author; Hang tian yi xue yu yi xue gong cheng = Space medicine & medical engineering; Feb 2000; ISSN 1002-0837; Volume 13, Issue 1, 14-8; In Chinese; Copyright; Avail: Other Sources

The equipment of using Azolla for O2-supplementation and food-production in future space station was developed and tested. Dog was used as the O2-consuming animal. The design of this device considered both the requirement of Azolla growth, such as illumination, temperature, humidity, nutrition and biomass harvesting, and also the food supplement, excretion draining and temperature controlling for the dog under the condition of an airtight chamber for a relatively long duration. This device was preliminarily tested for O2-release by Azolla, and data about O2-supplement by Azolla were obtained.

NLM

Closed Ecological Systems; Life Support Systems; Oxygen; Plants (Botany)

20040088690

Analysis of edible oil processing options for the BIO-Plex advanced life support system

Greenwalt, C. J., Author; Hunter, J., Author; Life support & biosphere science : international journal of earth space; 2000; ISSN 1069-9422; Volume 7, Issue 3, 233-42; In English; Copyright; Avail: Other Sources

Edible oil is a critical component of the proposed plant-based Advanced Life Support (ALS) diet. Soybean, peanut, and single-cell oil are the oil source options to date. In terrestrial manufacture, oil is ordinarily extracted with hexane, an organic solvent. However, exposed solvents are not permitted in the spacecraft environment or in enclosed human tests by National Aeronautics and Space Administration due to their potential danger and handling difficulty. As a result, alternative oil-processing methods will need to be utilized. Preparation and recovery options include traditional dehulling, crushing, conditioning, and flaking, extrusion, pressing, water extraction, and supercritical extraction. These processing options were evaluated on criteria appropriate to the Advanced Life Support System and BIO-Plex application including: product quality, product stability, waste production, risk, energy needs, labor requirements, utilization of nonrenewable resources, usefulness of by-products, and versatility and mass of equipment to determine the most appropriate ALS edible oil-processing operation.

NLM

Closed Ecological Systems; Fats; Food; Life Support Systems; Oils; Technologies

20010024956 NASA Ames Research Center, Moffett Field, CA USA

Separation of Carbon Monoxide and Carbon Dioxide for Mars ISRU-Concepts

LeVan, M. Douglas; Finn, John E.; Sridhar, K. R.; Proceedings of the Fifth Microgravity Fluid Physics and Transport Phenomena Conference; December 2000, 1204-1216; In English; No Copyright; Avail: CASI; A03, Hardcopy

Solid oxide electrolyzers, such as electrolysis cells utilizing yttria-stabilized zirconia, can produce oxygen from Mars atmospheric carbon dioxide and reject carbon monoxide and unreacted carbon dioxide in a separate stream. The oxygen-production process has been shown to be far more efficient if the high-pressure, unreacted carbon dioxide can be separated and recycled back into the feed stream. Additionally, the mass of the adsorption compressor can be reduced. Also, the carbon monoxide by-product is a valuable fuel for space exploration and habitation, with applications from fuel cells to production of hydrocarbons and plastics. In our research, we will design, construct, and test an innovative, robust, low mass, low power separation device that can recover carbon dioxide and carbon monoxide for Mars ISRU. Such fundamental process technology, involving gas-solid phase separation in a reduced gravitational environment, will help to enable Human Exploration and Development of Space. The separation device will be scaled to operate with a CO2 sorption compressor and a zirconia electrolysis device built at the NASA Ames Research Center and the University of Arizona, respectively. In our research, we will design, construct, and test an innovative, robust, low mass, low power separation device that can recover carbon dioxide and carbon monoxide for Mars ISRU, Such fundamental process technology, involving gas-solid phase separation in a reduced gravitational environment, will help to enable Human Exploration and Development of Space. The separation device will be scaled to operate with a CO2 sorption compressor and a zirconia electrolysis device built at the NASA Ames Research Center and the University of Arizona, The separation device will be scaled to operate with a CO2 sorption compressor and a zirconia electrolysis device built at the NASA Ames Research Center and the University of Arizona, Research needs for the design shown are as follows: (1) The best adsorbent for the process must be determined. (2) Adsorption isotherms must be measured, both for pure components and mixtures. (3) Mathematical modeling must be performed to provide a solid framework for design. (4) The separation system must be constructed and tested. (5) System integration must be studied.

Author (revised)

Mars Atmosphere; Carbon Dioxide; Carbon Monoxide; Electrolysis; Oxygen Production

20010001695 Tokyo Inst. of Tech., Tokyo, Japan

Experimental Study on Water Production by Hydrogen Reduction of Lunar Soil Simulant in a Fixed Bed Reactor

Yoshida, H.; Watanabe, T.; Kanamori, H.; Yoshida, T.; Ogiwara, S.; Eguchi, K.; Space Resources Roundtable II; [2000], 75; In English; No Copyright; Avail: Other Sources; Abstract Only

Human habitation on the moon will require utilization of lunar resource materials because of reducing cost of their transportation from Earth. Especially, oxygen is vital for life support and spacecraft propulsion. To this end, oxygen production from locally derived materials is of significance for future lunar exploration. Over 20 processes of the oxygen production on the moon have been proposed. Among them, oxygen production by hydrogen reduction is most feasible. In the oxygen production process, ilmenite contained in lunar soil is reacted with hydrogen for water production, and then oxygen is produced through electrolysis.

Derived from text

Experimentation; Data Acquisition; Water; Hydrogen; Electrolysis; Water Reclamation

20000121128 Lockheed Martin Engineering and Science Services, Moffett Field, CA USA

A Solid-State Compressor for Integration of CO2 Removal and Reduction Assemblies

Mulloth, Lila M.; Finn, John E.; Lung, Bernadette, Technical Monitor; [2000]; In English; Environmental Systems, 10-13 Jul. 2000, Toulouse, France

Contract(s)/Grant(s): RTOP 131-20-10; No Copyright; Avail: Other Sources; Abstract Only

Integration of CO2 removal and reduction assemblies in a spacecraft air revitalization system requires an interface with the functionality of a vacuum pump/compressor and a buffer tank. The compressor must meet the vacuum needs of the CO2 removal unit and the pressure needs of the CO2 reduction device, and must also store sufficient CO2 to accommodate the differences in cycle times of the two processes. In this presentation, we describe the design and operation of an adsorption-based device sized for use on the International Space Station. The adsorption compressor functions at a power level approximately ten times lower than a comparable mechanical compression/buffer tank system. The unit is also smaller, lighter, and quieter than its mechanical counterpart.

Author

Air Purification; Carbon Dioxide Removal; Compressors; Life Support Systems

20000115607 FDC/NYMA, Inc., Hampton, VA USA

A Study of a Lifting Body as a Space Station Crew Exigency Return Vehicle (CERV)

MacConochie, Ian O.; October 2000; In English

Contract(s)/Grant(s): NAS1-96013; RTOP 242-33-01-50

Report No.(s): NASA/CR-2000-210548; NAS 1.26:210548; No Copyright; Avail: CASI; A03, Hardcopy

A lifting body is described for use as a return vehicle for crews from a space station. Reentry trajectories, subsystem weights and performance, and costs are included. The baseline vehicle is sized for a crew of eight. An alternate configuration is shown in which only four crew are carried with the extra volume reserved for logistics cargo. A water parachute recovery system is shown as an emergency alternative to a runway landing. Primary reaction control thrusters from the Shuttle program are used for orbital maneuvering while the Shuttle verniers are used for all attitude control maneuvers.

Author

Lifting Bodies; Space Stations; Vehicles

20000114292 Institute of Space Medico-Engineering, Beijing, China

Effects of CO2 Concentration on Growth and Development of Lettuce in Controlled Environment

Guo, Shuang-Sheng; Ai, Wei-Dang; Space Medicine and Medical Engineering; Aug. 2000; ISSN 1002-0837; Volume 13, Issue No. 4, 267-271; In Chinese; Copyright; Avail: Other Sources

To study the tolerance of lettuce to elevated CO2 concentration in Controlled Ecological Life Support System(CELSS). Lettuce was cultivated in the Ground-based Experimental Facility for Higher Plant Cultivation in Space (GEFHPCS), in which many parameters were kept unchanged, while concentration of CO2 was controlled at 5 different levels (2000 approx. 10000 micro mol/ mol). During the growing periods, the morphologies of lettuce were observed every day, the replenished amounts of CO2 to GEFHPCS and water to the nutrient fluid box as well as the amounts of condensed water collected from GEFHPCS were all recorded every day. After harvest, the output and photosynthetic rate were calculated and lots of constituents of lettuce were analyzed. The growth of lettuce were relatively ideal when CO2 concentration was at 6000 micro mol/mol, but an obviously withering appearance was found when CO2 concentration increased 10000 micro mol/ mol this time the output and quality of lettuce were unsatisfactory. It would be optimal when CO2 concentration is controlled at about 6000 micro mol/mol in a lettuce-cultivating chamber.

Author

Carbon Dioxide Concentration; Vegetables; Growth; Closed Ecological Systems

20000114282 Institute of Space Medico-Engineering, Beijing, China

Design of Reaction Canister in a Solid Amine Carbon Dioxide Removal System

Zhou, Kang-Han; Lu, Xi-Yu; Liu, Xiang-Yang; Ai, Shang-Kun; Liu, Cheng-Liang; Space Medicine and Medical Engineering; Aug. 2000; ISSN 1002-0837; Volume 13, Issue No. 4, 272-276; In Chinese; Copyright; Avail: Other Sources

To design a reaction canister using in solid amine carbon dioxide removal system for long-duration spaceflight. On consideration of system demand and properties of solid amine, key problems must be solved were found out: 1) the rated resistance limit tends to shorten the length of the canister while absorption and concentration require to increase the length of the canister: 2) limited quantity of heat for keeping the temperature of the canister; 3) inflation or contraction of the solid amine under micro-gravity. After appropriate measures were taken, effective adsorption and desorption, as well as concentration of CO2 were achieved, the concentration of CO2 in the space cabin could be controlled below 0 - 5 %; and the concentration of the concentrated CO2 was as high as 98 % so that it could be directly send to the CO2 reduction system; and that the resistance of the canister was below 160 mm H2O; moreover , the energy consumption was decreased to below 650 W. The designed reaction canister could meet the requirements of the solid amine carbon bioxide removal system under microgravity.

Author

Design Analysis; Cans; Carbon Dioxide Removal; Desorption; Solidified Gases

20000109641 Institute of Space Medico-Engineering, Beijing, China

Development of a Ground-Based Experimental Facility for Space Cultivation of Higher Plant

Guo, Shuang-Sheng; Wang, Pu-Xiu; Hou, Ji-Dong; Ai, Wei-Dang; Chao, Zhao-Gang; Space Medicine and Medical Engineering; Feb. 2000; ISSN 1002-0837; Volume 13, Issue No. 1, 19-24; In Chinese; Copyright; Avail: Other Sources

A ground-based experimental facility was developed for conducting initial ground-based simulation study of Controlled Ecological Life Support System (CELSS). The facility is composed of a main chamber, O2 and CO2 composition control

subsystems, plant cultivation subsystem and whole data management subsystem. The growth room, being composed of a inner wall of mirror-face stainless steel, holds a volume of 1.8 cubic m and a growing area of 1.2 sq m; electronic fluorescent lamps were used as lighting sources and polyvinyl formal was used for root matrixes; the environmental parameters of the growing room such as temperature, relative humidity, O2 concentration, CO2 concentration, lighting period and irradiance intensity and the nutrient parameters such as pH, electrical conductivity, dissolved oxygen concentration, liquid level of nutrient storage tank and flow rate of nutrient were all controlled automatically; all of the above mentioned parameters can be inspected, collected, stored and printed regularly and dynamically. The results of a combined debugging and preliminary plant cultivation verified that the technical target of the facility had reached its initial design requirements, it can be used to conduct ground-based simulation studies of space cultivation of higher plants.
Author
Ground Based Control; Control Systems Design; Aerospace Systems; Closed Ecological Systems; Exobiology; Plants (Botany); Cultivation

20000085957 NASA Johnson Space Center, Houston, TX USA
Multi-Agent Diagnosis and Control of an Air Revitalization System for Life Support in Space
Malin, Jane T.; Kowing, Jeffrey; Nieten, Joseph; Graham, Jeffrey s.; Schreckenghost, Debra; Bonasso, Pete; Fleming, Land D.; MacMahon, Matt; Thronesbery, Carroll; [2000]; In English, 18-25 Mar. 2000, Big Sky, MT, USA
Contract(s)/Grant(s): RTOP 632-30-43; No Copyright; Avail: Other Sources; Abstract Only

An architecture of interoperating agents has been developed to provide control and fault management for advanced life support systems in space. In this adjustable autonomy architecture, software agents coordinate with human agents and provide support in novel fault management situations. This architecture combines the Livingstone model-based mode identification and reconfiguration (MIR) system with the 3T architecture for autonomous flexible command and control. The MIR software agent performs model-based state identification and diagnosis. MIR identifies novel recovery configurations and the set of commands required for the recovery. The AZT procedural executive and the human operator use the diagnoses and recovery recommendations, and provide command sequencing. User interface extensions have been developed to support human monitoring of both AZT and MIR data and activities. This architecture has been demonstrated performing control and fault management for an oxygen production system for air revitalization in space. The software operates in a dynamic simulation testbed.
Author
Air Purification; Architecture (Computers); Diagnosis; Life Support Systems; Autonomy; Spacecraft Environments

20000072884 NASA Marshall Space Flight Center, Huntsville, AL USA
International Space Station Carbon Dioxide Removal Assembly Testing
Knox, James C.; 2000; ISSN 0148-7191; In English; 30th, 10-13 Jul. 2000, Toulouse, France
Report No.(s): 00ICES-234; No Copyright; Avail: CASI; A03, Hardcopy

Performance testing of the International Space Station Carbon Dioxide Removal Assembly flight hardware in the USA Laboratory during 1999 is described. The CDRA exceeded carbon dioxide performance specifications and operated flawlessly. Data from this test is presented.
Author
Carbon Dioxide Removal; International Space Station; Performance Tests; Decontamination; Closed Ecological Systems; Exobiology; Spacecraft Environments; Spacecraft Equipment

20000072483 NASA Marshall Space Flight Center, Huntsville, AL USA
Living and Working in Space
Roman, Monserrate C.; [2000]; In English, 6-11 Jun. 2000, Carolina, Puerto Rico; No Copyright; Avail: CASI; A03, Hardcopy

This document is a presentation about some of the challenges of living and working in space. The presentation shows slides of the Apollo 11 liftoff, Skylab in orbit, a Space Shuttle launch, and a slide of the International Space Station. It reviews the needs and effluents of the astronauts per day, and the Environmental Control and Life Support (ECLS) systems. It shows a flow diagram of the Space Station Regenerative ECLS, which shows the various systems, and how they interact to control the environment and recycle the air, and water. There are other slides some of which show astronauts eating, brushing teeth, shaving, and sipping from a sip bottle while exercising.
CASI
Environmental Control; Life Support Systems; Water; Closed Ecological Systems; Oxygen Supply Equipment; Spacecraft Environments; Waste Management; Oxygen Production; Waste Disposal

20000068485 NASA Marshall Space Flight Center, Huntsville, AL USA

International Space Station Environmental Control and Life Support System Status: 1999-2000

Reuter, James L.; [2000]; In English, 10-13 Jul. 2000, Toulouse, France

Report No.(s): Rept-00ICES-216; Copyright; Avail: Other Sources

The International Space Station (ISS) Environmental Control and Life Support (ECLS) system includes regenerative and non-regenerative technologies which provide the basic life support functions to support the crew, while maintaining a safe and habitable shirtsleeve environment. This paper provides a summary of the U.S. ECLS system activities over the past year, covering the period of time between May 1999 and April 2000. Assembly of the ISS has been delayed due ot changes in element processing schedules. The 2A.1 logistics flight to ISS occurred in May 1999. The remaining Phase 2 elements have completed most of the element level testing and integration and are approaching final reviews for acceptance for flight. The Phase 3 regenerative ECLS designs have reached the Critical Design Review phase, while several of the Phase 3 elements have held Preliminary of Critical Design Reviews.

Author

Environmental Control; International Space Station; Life Support Systems; Space Missions

20000068483 NASA Marshall Space Flight Center, Huntsville, AL USA

International Space Station Sustaining Engineering: A Ground-Based Test Bed for Evaluating Integrated Environmental Control and Life Support System and Internal Thermal Control System Flight Performance

Ray, Charles D.; Perry, Jay L.; Callahan, David M.; [2000]; In English; 30th, 10-13 Jul. 2000, Toulouse, France; No Copyright; Avail: CASI; A03, Hardcopy

As the International Space Station's (ISS) various habitable modules are placed in service on orbit, the need to provide for sustaining engineering becomes increasingly important to ensure the proper function of critical onboard systems. Chief among these are the Environmental Control and Life Support System (ECLSS) and the Internal Thermal Control System (ITCS). Without either, life onboard the ISS would prove difficult or nearly impossible. For this reason, a ground-based ECLSS/ITCS hardware performance simulation capability has been developed at NASA's Marshall Space Flight Center. The ECLSS/ITCS Sustaining Engineering Test Bed will be used to assist the ISS Program in resolving hardware anomalies and performing periodic performance assessments. The ISS flight configuration being simulated by the test bed is described as well as ongoing activities related to its preparation for supporting ISS Mission 5A. Growth options for the test facility are presented whereby the current facility may be upgraded to enhance its capability for supporting future station operation well beyond Mission 5A. Test bed capabilities for demonstrating technology improvements of ECLSS hardware are also described.

Author

Ground Tests; Test Facilities; Environmental Control; Life Support Systems; Simulation; Flight Characteristics

20000044327 NASA Marshall Space Flight Center, Huntsville, AL USA

Using Modern Design Tools for Digital Avionics Development

Hyde, David W.; Lakin, David R., II; Asquith, Thomas E.; [2000]; In English; 19th, 7-12 Oct. 2000, Philadelphia, PA, USA

Contract(s)/Grant(s): RTOP 477-72-W3; No Copyright; Avail: Other Sources; Abstract Only

Using Modem Design Tools for Digital Avionics Development Shrinking development time and increased complexity of new avionics forces the designer to use modem tools and methods during hardware development. Engineers at the Marshall Space Flight Center have successfully upgraded their design flow and used it to develop a Mongoose V based radiation tolerant processor board for the International Space Station's Water Recovery System. The design flow, based on hardware description languages, simulation, synthesis, hardware models, and full functional software model libraries, allowed designers to fully simulate the processor board from reset, through initialization before any boards were built. The fidelity of a digital simulation is limited to the accuracy of the models used and how realistically the designer drives the circuit's inputs during simulation. By using the actual silicon during simulation, device modeling errors are reduced. Numerous design flaws were discovered early in the design phase when they could be easily fixed. The use of hardware models and actual MIPS software loaded into full functional memory models also provided checkout of the software development environment. This paper will describe the design flow used to develop the processor board and give examples of errors that were found using the tools. An overview of the processor board firmware will also be covered.

Author

Circuits; Computer Programming; Computer Programs; Digital Simulation; Hardware Description Languages; Simulation; Water Reclamation

Subject Terms

Corporate Sources

Document Authors