

# **30th IAA Symposium on Space and Society 2019**

Held at the 70th International Astronautical  
Congress (IAC 2019)

Washington, DC, USA  
21-25 October 2019

ISBN: 978-1-7138-1502-0

**Printed from e-media with permission by:**

Curran Associates, Inc.  
57 Morehouse Lane  
Red Hook, NY 12571



**Some format issues inherent in the e-media version may also appear in this print version.**

Copyright© (2019) by International Astronautical Federation  
All rights reserved.

Printed with permission by Curran Associates, Inc. (2020)

For permission requests, please contact International Astronautical Federation  
at the address below.

International Astronautical Federation  
100 Avenue de Suffren  
75015 Paris  
France

Phone: +33 1 45 67 42 60

Fax: +33 1 42 73 21 20

[www.iafastro.org](http://www.iafastro.org)

**Additional copies of this publication are available from:**

Curran Associates, Inc.  
57 Morehouse Lane  
Red Hook, NY 12571 USA  
Phone: 845-758-0400  
Fax: 845-758-2633  
Email: [curran@proceedings.com](mailto:curran@proceedings.com)  
Web: [www.proceedings.com](http://www.proceedings.com)

# TABLE OF CONTENTS

## **SPACE ARCHITECTURE: HABITATS, HABITABILITY, AND BASES**

|   |    |
|---|----|
| NASA REQUIREMENTS DEVELOPMENT FOR LUNAR IN-SITU SURFACE<br>CONSTRUCTION OF INFRASTRUCTURE .....                         | 1  |
| <i>Robert Moses, Robert Mueller, Gerald Sanders</i>   |    |
| INTERIOR CONFIGURATION CONCEPTS FOR THE GATEWAY IHAB .....  | 2  |
| <i>René Waclavicek, Robert Davenport, Anna Barbara Imhof, Waltraut Hoheneder, Michael Labidi</i>                        |    |
| BOEING NEXTSTEP EFFORTS IN SUSTAINABLE LUNAR EXPLORATION .....  | 9  |
| <i>Matthew Duggan, Travis Moseman, David Pederson</i>   |    |
| THE DEVELOPMENT OF FUTURE SPACE STATIONS FROM UPPER STAGES .....  | 16 |
| <i>Samuel Wald</i>  |    |
| REDESIGN OF SALYUT STATION FOR DUAL-USE OF RESEARCH AND TOURISM.....  | 17 |
| <i>Tamalee Basu, Anastasia Prosina, Ayda Uraz</i>   |    |
| DEFINING BEST DESIGN PRACTICES FOR SAFETY AND COMFORT IN MOON AND<br>MARS HABITATS .....                                | 26 |
| <i>Tatiana Volkova, Claude Nicollier, Volker Gass</i>   |    |
| REDUCED GRAVITY EXPERIMENT: INVESTIGATING THE EFFECTS OF REDUCED<br>GRAVITY ON CIRCULATION IN HABITAT ARCHITECTURE..... | 40 |
| <i>Karl-Johan Sørensen, Sebastian Aristotelis, Filip Eckerdal</i>   |    |
| A CASE FOR THE SPACE BATHROOM .....   | 41 |
| <i>Zachary Taylor</i>   |    |
| NASA CENTENNIAL CHALLENGE:THREE DIMENSIONAL (3D) PRINTED HABITAT,<br>PHASE III COMPETITION OUTCOMES.....                | 49 |
| <i>Robert Mueller, Monsi Roman, Hong Soo (Tony) Kim, Tracie Prater, Jennifer Edmunson, Michael Fiske, Peter Carrato</i> |    |
| PROTOTYPING MARSHA: DISCOVERIES, SURPRISES AND LESSONS IN ADDITIVE<br>HABITAT CONSTRUCTION.....                         | 62 |
| <i>Jeffrey Montes, Christopher James Botham, James Earle, James Coleman, David Riedel</i>                               |    |
| FIBER REINFORCED POLYETHYLENE-BASALT COMPOSITES - FABRICATION AND<br>TESTING .....                                      | 71 |
| <i>Nicholas McGhee</i>  |    |
| A DANGEROUS PRECEDENT; THE GEODESIC DOME AS A CREDIBLE SPACE<br>ARCHITECTURE TYPOLOGY .....                             | 78 |
| <i>Craig McCormack, Taylor Phillips-Hungerford</i>  |    |
| SPACE HABITAT RECONFIGURABILITY: TESSERAE PLATFORM FOR SELF-AWARE<br>ASSEMBLY.....                                      | 87 |
| <i>Ariel Ekblaw, Anastasia Prosina, Dava J. Newman, Joseph Paradiso</i>   |    |

|   |     |
|---|-----|
| ANALOGUE RESEARCH PERFORMED AT THE HI-SEAS RESEARCH STATION IN HAWAII, AS PART OF THE EUROMOONMARS CAMPAIGN.....  | 99  |
| <i>Michaela Musilova, Bernard Foing, Nityaporn Sirikan, Annelotte Weert, Sebastian Mulder, Benjamin Pothier, Joshua Burstein, Henk Rogers</i>   |     |
| ILEWG BTU IGLUNA SMART ICE LAB.....   | 101 |
| <i>Anna Sitnikova, Bernard Foing, Tatiana Benavides, Ariane Wanske, Lyubov Dimova, Irene Lia Schlacht, Bram De Winter, Marc Heemskerk, David Moritz, Martin Loeffler</i>                  |     |
| REUTILIZE AN EMPTY SLS UPPER STAGE HYDROGEN TANK INTO HABITATION MODULE FOR LUNAR ORBITAL PLATFORM-GATEWAY.....   | 103 |
| <i>Shunsuke Miyazaki</i>  |     |
| BUBBLE ONE – SCALABLE SHIRT SLEEVE SPACE CONSTRUCTION SYSTEM UTILIZING INFLATABLE MOLDS AND SPACE RESOURCES.....  | 117 |
| <i>Rick Tumlinson</i>   |     |
| THE REMNANT PROJECT: BUILDING A SELF-SUSTAINABLE LUNAR HABITAT FOR LONG-TERM HUMAN MISSIONS TO THE MOON.....  | 118 |
| <i>Roberto Rodriguez, Joshua Castro</i>   |     |
| RESULTS OF THE AIAA PHOBOS BASE STUDENT DESIGN COMPETITION.....   | 123 |
| <i>Marc M. Cohen, Edward Hodgson, Donna Rodman</i>  |     |
| MARTIAN GREENHOUSE ARCHITECTURE: ENABLING HABITABILITY, SAFETY AND AESTHETICS.....  | 141 |
| <i>Mahsa Moghimi Esfandabadi, Olga Bannova</i>  |     |
| HYBRID HABITAT FOR MARS: CREATING COMFORT WITH LIGHT.....   | 149 |
| <i>Layla Van Ellen</i>  |     |
| <b><u>IS SPACE R&amp;D TRULY FOSTERING A BETTER WORLD FOR OUR FUTURE?</u></b>   |     |
| UNDERSTANDING THE POTENTIAL ECONOMIC AND SOCIETAL IMPACT, OF PATENTING SPACE TECHNOLOGY AS A TOOL FOR TECHNOLOGY TRANSFER.....  | 154 |
| <i>Luis Monge</i>   |     |
| ADDRESSING SOCIETAL NEEDS THROUGH A FUTURE ANTARCTIC RESEARCH MISSION FOR SPACE HABITATS, AND PSYCHOLOGICAL ADAPTATION, AS WELL AS FOSTERING INNOVATIVE CROSS-INDUSTRY COLLABORATION..... | 155 |
| <i>Nancy C. Wolfson, Megan Kane</i>   |     |
| WHAT HORTICULTURE AND SPACE EXPLORATION CAN LEARN FROM EACH OTHER: THE MISSION TO MARS INITIATIVE IN THE NETHERLANDS .....  | 158 |
| <i>Angelo C. J. Vermeulen, Coen Hubers, Liselotte De Vries, Frances Brazier</i>   |     |
| SUSTAINABILITY VERSUS EXPONENTIAL GROWTH IN IN-SITU RESOURCE UTILIZATION (ISRU) RESEARCH AGENDAS .....  | 163 |
| <i>Tamara Alvarez</i>   |     |
| PRIVATE SECTOR EMPOWERMENT FOR DOMESTIC LONG-TERM SUSTAINABLE SPACE DEVELOPMENT .....   | 166 |
| <i>Nammi Choe, Mijin Yoo</i>  |     |

|  |     |
|--|-----|
| THE NEW GLOBAL GOVERNANCE IN THE AEROSPACE INDUSTRY: NEW TECHNOLOGICAL CAPABILITIES IN BRAZIL, CHINA AND CANADA .....  | 169 |
| <i>Sofía Andrea Huerta Ramírez</i>   |     |
| SPACE TECHNOLOGY WITH SYSTEMS THEORY – BENEFIT TO SOCIETY .....  | 178 |
| <i>Sias Mostert</i>  |     |
| SPACE R&D TO ENHANCE LIVE IN EMERGING SPACE COUNTRIES IN AFRICA AND LATIN AMERICA.....   | 179 |
| <i>Annette Froehlich, Mehak Sarang, André Siebrits</i>   |     |
| INCREASE QUANTUM COMPUTING TECHNOLOGY READINESS LEVEL THROUGH EXPERIMENTATION IN SPACE.....  | 186 |
| <i>Giuseppe Correale, Gianluca Cerrone, Zaid Al Ars, Koen Bertels</i>  |     |
| ANALYSIS AND PERSPECTIVES OF THE SPACE SECTOR IN PUBLIC POLICY OF SCIENCE, TECHNOLOGY AND INNOVATION IN MEXICO: RECOMMENDATIONS FROM YOUNG STUDENTS AND PROFESSIONALS .....  | 190 |
| <i>Tania María Robles Hernández, Juan Carlos Mariscal</i>  |     |
| VALUE GENERATION THROUGH PUBLIC PROCUREMENT OF INNOVATIVE EARTH OBSERVATION APPLICATIONS: SERVICE-DOMINANT LOGIC PERSPECTIVE .....   | 191 |
| <i>Tõnis Eerme, Niina Nummela</i>  |     |
| THE BUSINESS-ORIENTED ADVANCED TECHNOLOGY LUXEMBOURG SPACE RESOURCES RESEARCH CENTER (LS2RC) .....   | 205 |
| <i>Mathias Link, Bob Lamboray, Gary Martin</i>   |     |
| ROADMAP TO RESPONSIBLE AND SUSTAINABLE BUILDING ON MARS.....   | 209 |
| <i>Agata Mintus</i>  |     |
| WOMEN, STEM (SCIENCE, TECHNOLOGY, ENGINEERING AND MATHEMATICS) AND THE R&D INVESTMENT TO IMPROVE THE AEROSPACE TECHNOLOGY IN THE DEVELOPING WORLD. CASE STUDY: EL SALVADOR AND GENDER EQUALITY .....               | 210 |
| <i>Luis Alfaro</i>   |     |
| <b><u>CONTEMPORARY ARTS PRACTICE AND OUTER SPACE: A MULTI-DISCIPLINARY APPROACH</u></b>  |     |
| LOVE LETTER TO A SPACE ROCK: A DECLARATION OF LOVE TO THE ALLENDE METEORITE THROUGH CONTEMPORARY ART .....   | 211 |
| <i>Cintia Durán</i>  |     |
| DIARY OF A MARTIAN BEEKEEPER' THEATRE SHOW, EXPLORING LONG-DURATION MISSIONS, THE HUMAN CONDITION AND BEEKEEPING.....  | 212 |
| <i>Niamh Shaw, Clair McSweeney, Niall Smith, Stephanie O'Neill, Cathy Foley, Sarah Baxter, Ger Clancy, Aoife White, Bill Woodlnad, Aine O'Hara, Aidan Cowley, Jules Grandsire, Lorraine Conroy, Juan De Dalmau</i> |     |
| KEYNOTE: THE OVERVIEW EFFECT AND THE ARTS .....  | 214 |
| <i>Frank White</i>   |     |
| THE UNSEEN WORLDS: USING FEATURE FILM TECHNIQUES FOR SPACE MISSION PLANNING.....   | 220 |
| <i>Lizbeth B. De La Torre, Artur B. Chmielewski, Danielle Wood</i>   |     |

|  |     |
|--|-----|
| THE SPACE FARMING PROJECT: SPACE COLONIZATION, TECHNO-AGRICULTURE<br>AND THE FUTURE OF EXTRATERRESTRIAL BIOPOLITICS .....                              | 227 |
| <i>Angelo C. J. Vermeulen, Ramona Van Gansbeke, Nick Pannecoucq, Rufin Degrande, Bart<br/>Leenknecht, Christophe De Jaeger, Frances Brazier</i>        |     |
| SPACE EXPLORATION AS A CULTURAL OBJECT: HOW AND WHY SPACE AGENCIES<br>SHOULD ENGAGE WITH ARTISTS .....   | 233 |
| <i>Andrew Kuh</i>  |     |
| COGITO IN SPACE AT THE DWINGELOO RADIO TELESCOPE .....   | 237 |
| <i>Daniela De Paulis</i>   |     |
| UNCERTAIN GARDEN – SPACE DESIGN FOR FERTILIZING UNCERTAINTY AT<br>IDEASQUARE, CERN .....   | 240 |
| <i>Yuri Tanaka, Hajime Shimoyama</i>   |     |
| GIANT STEP: THE HEARTBEAT AND WORDS OF NEIL ARMSTRONG RETURNED TO<br>THE MOON .....  | 246 |
| <i>Richard Clar</i>  |     |
| CHOREOGRAPHIC TECHNIQUES FOR HUMAN BODIES IN WEIGHTLESSNESS .....  | 252 |
| <i>Robert Dipert</i>   |     |
| CURATING THE HUMAN EXPERIENCE OF SPACE—A COLLABORATIVE, INCLUSIVE<br>APPROACH.....   | 267 |
| <i>Xin Liu</i>   |     |
| MOON GALLERY .....   | 275 |
| <i>Anna Sitnikova, Bernard Foing, Alexander Zaklynsky, Elizaveta Glukhova, Tatiana<br/>Benavides, Anastasia Izotova</i>                                |     |
| THE VALUE OF ART AS AN URBAN INTERVENTION FOR EXTRATERRESTRIAL<br>SETTLEMENTS AND ITS IMPACT ON THE SUBCONSCIOUS PERCEPTION OF TIME AND<br>SPACE ..... | 280 |
| <i>Monika Lipinska, Weronika Sojka</i>   |     |
| APOLLO AND THE MUSES: CULTURAL AND TECHNICAL INSPIRATIONAL<br>KNOWLEDGE EMBEDDED IN LUNAR SPACE ARTS .....   | 288 |
| <i>Sarah Jane Pell, David G. Barnes</i>  |     |

## **SPACE ASSETS AND DISASTER MANAGEMENT**

|   |     |
|---|-----|
| COPERNICUS LEGAL CHALLENGES WITH OPEN DATA POLICIES IN CASE OF<br>DISASTERS.....  | 302 |
| <i>Sandra Cabrera Alvarado</i>  |     |
| MORAZÁN PROJECT: POTENTIAL IMPACT ON THE DEVELOPMENT OF TECHNICAL<br>INTERNATIONAL COOPERATION IN CENTRAL AMERICA, SPECIFICALLY BETWEEN<br>COSTA RICA - HONDURAS – GUATEMALA..... | 303 |
| <i>Vivian Calderón Pérez, Carlos Enrique Alvarado-Briceño</i>   |     |
| SPATIO-TEMPORAL ANALYSIS OF OIL SPILLS IN THE PERUVIAN AMAZON.....  | 304 |
| <i>Natalia Indira Vargas-Cuentas, Avid Roman-Gonzalez</i>   |     |

|   |     |
|---|-----|
| A SUMMARY OF THE UNITED STATES'S NATIONAL NEAR-EARTH OBJECT<br>PREPAREDNESS STRATEGY AND ACTION PLAN. ....  | 310 |
| <i>Lindley Johnson, Doris Daou, Kelly Fast, Victoria Friedensen, Rob Landis</i>   |     |
| LAPAN-A2 (IO-86) SATELLITE ROLES IN NATURAL DISASTER IN INDONESIA .....   | 317 |
| <i>Wahyudi Hasbi</i>  |     |
| COMBINING SPACE DATA WITH AI TECHNIQUES TO IMPROVE DISASTER RESPONSE<br>TIMES .....   | 322 |
| <i>James Parr</i>   |     |
| NEW FUNCTIONALITIES OF THE EUROPEAN FOREST FIRE INFORMATION SYSTEM<br>WHICH ADVANCE DISASTER MANAGEMENT AND SUSTAINABLE DEVELOPMENT<br>GOALS..... | 323 |
| <i>Pierre-Alexis Lagadrilliere, Michael Nolde, Torsten Riedlinger, Thomas Ruppert, Maximilian Schwinger</i>                                       |     |
| SPACE TECHNOLOGIES USED IN THE MANAGEMENT AND RISK REDUCTION OF<br>NATURAL DISASTER IN LATIN AMERICA: A SYSTEMATIC LITERATURE REVIEW .....        | 330 |
| <i>Glaysse Ferreira Perroni Da Silva, Ana Lucia Pegetti, Maria Teresa Piacesi, Mischel Carmen Belderrain</i>                                      |     |
| FIXING THE GLOBAL CARBON CRISIS WITH SPACE DEVELOPMENT .....  | 340 |
| <i>Jennifer Bolton, Kim Peart</i>   |     |
| SPACE TECHNOLOGIES FOR WILDFIRE MONITORING BY GOVERNMENTAL<br>ORGANIZATIONS .....   | 344 |
| <i>Samuel Looper, Ridwan Howlader, Adrián Vidal De Prados, Timothy Peterson</i>   |     |
| NASA EARTH SCIENCE ACTIVITIES SUPPORTING RESPONSE TO AND PREPAREDNESS<br>FOR NATURAL DISASTERS .....  | 354 |
| <i>Andrew Molthan, Lori Schultz, Jordan Bell, Michael Goodman, David Green, Garrett Layne</i>   |     |
| CITIZEN SCIENCE - AN IDEA TO INTEGRATE SCIENCE INTO OUR DIGITIZED WORLD .....   | 360 |
| <i>Peter Pusztai, Judit Turi</i>  |     |
| <b><u>SHARING SPACE ACHIEVEMENTS AND HERITAGE: SPACE MUSEUMS AND SOCIETIES</u></b>  |     |
| LEARNING FROM THE PAST TO INFORM THE FUTURE .....   | 368 |
| <i>Jennifer Levasseur</i>   |     |
| IN THE MOOD FOR THE MOON... CITÉ DE L'ESPACE AND THE APOLLO<br>ANNIVERSARY, REFLECTING ON THE PAST, LOOKING AT THE FUTURE.....                    | 382 |
| <i>Ines Prieto</i>  |     |
| REMEMBERING THE NEXT APOLLO: CHALLENGES TO PRESERVING AND<br>PRESENTING THE NEXT 50 YEARS OF SPACEFLIGHT.....                                     | 383 |
| <i>Geoff Nunn</i>   |     |
| CELEBRATING THE 50TH ANNIVERSARY OF THE FIRST PERSON ON THE MOON IN<br>THE NETHERLANDS .....  | 393 |
| <i>Peter Batenburg, Zeholy Pronk, Rob Van Den Berg, Sebastiaan De Vet</i>   |     |

|   |     |
|---|-----|
| INTERNATIONAL COLLABORATION STRATEGIES FOR THE INTERNATIONAL<br>ASTRONOMICAL UNION'S 100TH ANNIVERSARY CELEBRATIONS (IAU100)..... | 399 |
| <i>Bethany Downer, Jorge Rivero Gonzalez, Lina Canas, Pedro Russo, Sze-Leung Cheung,<br/>Ewine Van Dishoeck, Nelly Ivanova</i>    |     |

|  |     |
|--|-----|
| MONSTERS OF THE PLANETARY WEATHER: INTERACTIVE MUSEUM INSTALLATION<br>ON EXTREME CLIMATES IN THE SOLAR SYSTEM..... | 410 |
| <i>Cintia Durán</i>  |     |

|   |     |
|---|-----|
| ONE SMALL STEP? COLLECTION STRATEGIES FOR LIBRARIES, ARCHIVES, AND<br>MUSEUMS IN THE SPACE AGE..... | 411 |
| <i>Reagan Grimsley</i>  |     |

**INTERACTIVE PRESENTATIONS - 30TH IAA SYMPOSIUM ON SPACE AND SOCIETY**

|   |     |
|---|-----|
| PRESERVING AND SHARING AEROSPACE HISTORY THROUGH CROSS<br>GENERATIONAL AND INTERACTIVE COLLABORATIVE ACTIVITIES ..... | 417 |
| <i>Rachel Tillman</i>   |     |

|  |     |
|--|-----|
| SCRUM AND THE ART OF INTERNATIONAL SPACE LAW ..... | 418 |
| <i>Amanda Fuisz, David Lopez</i>                   |     |

|   |     |
|---|-----|
| SPACE SATELLITES FOR A HEALTHY EARTH..... | 429 |
| <i>Wendy Vasquez</i>                      |     |

|  |     |
|--|-----|
| TECHNICAL AND ECONOMIC ASSESSMENT OF ISRU AND NON-ISRU LUNAR<br>HABITAT RADIATION SHIELD ..... | 430 |
| <i>Chris Spedding</i>  |     |

|  |     |
|--|-----|
| A CASE STUDY OF HUMAN FACTOR & ANTHROPOLOGICAL INVESTIGATIONS IN<br>SPACE MISSION SIMULATIONS AND ANALOGS.....       | 431 |
| <i>Benjamin Pothier, Irene Lia Schlacht, Michaela Musilova, Alessandro Alcibiade, Bernard<br/>Foing, Henk Rogers</i> |     |

|   |     |
|---|-----|
| SPACE SOLUTION TO WORLD'S WATER CRISIS: A CASE STUDY WITH REMOTE<br>SENSING, SCIENCE AND TECHNOLOGY IN SYNERGY .....                            | 437 |
| <i>Miracle Israel Nazarious, Abhilash Vakkada Ramachandran, Anshuman Bhardwaj,<br/>Shaktiman Singh, María-Paz Zorzano, Javier Martín-Torres</i> |     |

|   |     |
|---|-----|
| AUSTRALIAN SPACE AGENCY - A BRAND STORY DRAWING ON AUSTRALIA'S PAST,<br>PRESENT AND FUTURE..... | 439 |
| <i>Sian Keys, Karl Rodrigues</i>  |     |

|  |     |
|--|-----|
| ASTRO-TOURISMS: A CONCEPT AND POSSIBILITY IN NEPAL ..... | 440 |
| <i>Sabin Gautam</i>                                      |     |

|   |     |
|---|-----|
| UAE SPACE AGENCY EFFORTS ON SPREADING AWARENESS OF THE UAE SPACE<br>SECTOR..... | 441 |
| <i>Maitha Al Romaithi</i>   |     |

|  |     |
|--|-----|
| WITHOUT SPACE .....  | 442 |
| <i>Bal Dhital, Lolowa Alkindi, David Girou, William Grand-Maison, Simon Jenner, Evon<br/>Koprowski, Juan Li, Erin Madden, Sonny Massahi, Michael Siddall</i> |     |

|   |     |
|---|-----|
| HUMAN SUSTAINABILITY BY SPACE ENGINEERING ..... | 457 |
| <i>Ildiko Tulbure, Dorin Prunariu</i>           |     |

**Author Index**