

# SAFETY DESIGN for SPACE OPERATIONS



Edited by  
Firooz A. Allahdadi  
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Editor-in-Chief  
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# Safety Design for Space Operations

*This book is dedicated to the memory of Jon Collins  
and Georg Koppenwallner*

# Safety Design for Space Operations

Editor-in-Chief

**Tommaso Sgobba**

Editors

**Firooz A. Allahdadi**

**Isabelle Rongier**

**Paul D. Wilde**

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# Preface

The adventure of space exploration has come to a new crossroads in its history. After several decades of ambitious space programs that entailed cooperation between different states and space agencies, the industry is moving in new directions such as commercial access to space and new missions to explore other bodies in the solar system. It is impossible to imagine any of these programs going ahead unless safety is granted absolute priority for all aspects of the mission. I should like to quote Albert Einstein, who wrote “*Concern for man and his fate must always form the chief interest of all technical endeavours.*” But good intentions alone will not suffice and, in view of the inherent dangers of the space environment and planetary exploration, risk mitigation is more critical than ever and must be supported with constant scientific and technical research.

There is consequently a need — but also an opportunity — to develop closer international cooperation both in terms of the players involved and the regulatory authorities, to guarantee the success of these new missions. In this field as in others, we must call on one of the most remarkable characteristics of space exploration, which has created a genuine international community prepared to share its experiences for the future benefit of all.

I see the publication of this book as a fine and promising example of the pooling of experience acquired in the safety issues surrounding space operations, for the benefit of public safety and the protection of the environment. I am certain that the relationships and the dynamic created during this project will contribute to future success in international scientific and technical cooperation in this field. It therefore gives me great pleasure to commend this work and I wish it the success it deserves.

*Yannick d'Escatha*  
*CNES President*



# About the Editors and Contributors

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Founding Fellow Member of the International Association for the Advancement of Space Safety (IAASS), and chairman of the IAASS Award Committee.

Dr. Firooz Allahdadi served (1998–2011) at the United States of America HQ Air Force Safety Center in multiple capacities. He was the Center’s Senior Technical Advisor, Director of Space Safety Division and the Department of Defense (DoD) representative in the presidentially mandated Inter-Agency Nuclear Safety Review Panel.



In 1998 Dr. Allahdadi employed rigorous scientific analysis to revamp the Air Force’s conventional weapons operational safety and guidelines. This undertaking produced measurable operational efficiency and considerable real estate savings. He pioneered the Directed Energy Weapons (DEW) Safety initiative leading teams of experts to identify and quantify the entire DEW hazards spectrum. He authored the governing DEW operation safety policies, AFD 91-4, which has been benchmarked throughout US military.

As the DoD representative, Dr. Firooz Allahdadi oversaw special analysis, provided technical oversight and garnered Presidential Launch authorization for the two Martian launches “Spirit” and “Opportunity” in 2003, the “New Horizons Mission,” a journey to Pluto in 2005, and landing of the nuclear-powered Rover “Curiosity” on the surface of Mars in 2010.

He founded and directed the Space Kinetic Impact and Debris Division (1990–1998) at the Air Force Research Laboratory. He led teams of scientists and engineers to develop high-fidelity analytical tools to predict dynamics of the debris clouds created from any space engagements. This technology was employed to simulate specific space scenarios for national security planning.

Dr. Firooz Allahdadi lectured on transport phenomenon and conducted research on several nationally important programs as a faculty member at University of New Mexico. He is a member of the National Research Council, Chief Editor of the International Society for Optical Engineering and has authored over 75 scientific papers.

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From 1997 to 2005, Isabelle Rongier served as head of system department and senior expert on flight management, including trajectory optimization, GNC algorithms design and validation, on-board flight software design and qualification and transient phases analysis. All these skills are necessary assets for performing safety analyses.



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Dr. Paul Wilde was a leader in the development of several major US regulations and standards on launch and re-entry risk management. For example, he was the lead author for five of the eleven chapters in the US national standard on range operations risk acceptability requirements, rationale, and implementation guidelines. Dr. Paul Wilde was co-chair of the Common Standards Working Group during the development of the FAA regulation on launch safety, and a principal author for the FAA's *Flight Safety Analysis Handbook*. He has published over 100 technical reports and papers. He received the NASA Exceptional Achievement Medal, Special Congressional Recognition, and several other awards. He is a licensed professional engineer in Texas, with degrees in Mechanical Engineering from the University of California.

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Tommaso Sgobba holds an M.S. in aeronautical engineering from the Polytechnic of Turin (Italy), where he was also professor of space system safety (1999–2001). He has published several articles and papers on space safety, and co-edited the textbook *Safety Design for Space Systems*, published in 2009 by Elsevier, that was also published later in Chinese. He co-edited the book entitled *The Need for an Integrated Regulatory*



*Regime for Aviation and Space*, published by Springer in 2011. He is a member of the editorial board of the *Space Safety Magazine*.

Tommaso Sgobba received the NASA recognition for outstanding contribution to the International Space Station in 2004, and the prestigious NASA Space Flight Awareness (SFA) Award in 2007.

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Received a Ph.D. in geophysics from Harvard University, and is now a senior scientist and program manager at ACTA, Inc, in Torrance, CA. He primarily supports the US Federal Aviation Administration and Department of Defense agencies in space vehicle risk software development and flight safety analysis.

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Worked 32 years at European Space Agency (ESA) on different spacecraft projects, including Automated Transfer Vehicle and Columbus Module for ISS in the area of development checkout systems. He chaired the ESA manned projects Ground

Segment Control Board (GSCB) and of the Security Control Board (SCB). He represented ESA in the ISS Security Assessment and Report Team (SART).

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### **Carine LEVEAU**

Leads the technical department of the Launcher Directorate of Centre National d'Etudes Spatiales (CNES) in charge of guidance, navigation and control (GNC), trajectory and safety during flight. She joined CNES in 2002 working for 3 years at the European Spaceport in Kourou, French Guiana. She managed technical activities related to Ariane 5 and VEGA stages re-entry, and was also responsible for the latest Ariane 5 main stage observation campaign.

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### **Eugene LEVIN, Ph.D.**

Leading expert on space tether dynamics, the author of two books on the subject. He worked on various projects with NASA, and US Air Force and Navy. He is currently working with the US Naval Research Laboratory on the flight demonstration of electrodynamic propulsion.

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### **Michael G. LUTOMSKI**

Has worked for 27 years at NASA on Manned Spaceflight Programs. Currently he is risk manager for the International Space Station (ISS) program. He is responsible for defining and implementing the qualitative and quantitative risk management processes across the entire program to assist the ISS management in making risk-informed decisions.

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### **Kelli MALONEY**

Mechanical Design Engineer with NASA, Kennedy Space Center, Florida since 2002. Lead Design Engineer for the Constellation Program Ground Emergency Egress System and Crew Access Arm designs. Currently Lead Mechanical Designer for the new Space Launch System's Crew Access Arm and the Ground Emergency Egress design engineering representative.

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### **Ronald R. MIKATARIAN**

BS in aeronautical engineering from Rensselaer Polytechnic Institute and an MS in mechanical engineering/fluid mechanics from the University of Santa Clara. He has worked for over 50 years in the areas of fluid dynamics, plasma physics and chemistry and is a member of Boeing Research and Technology. He is at present the Boeing Space Environments Manager on the International Space Station.

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System safety engineer at The Boeing Company, he has over 30 years experience in aerospace program system safety. Received a Bachelor of Science degree in mechanical engineering from the University of Michigan-Dearborn, a Master in Business Administration project management degree from National University, and a dual Master of Science degree in aeronautical sciences/operations from Embry-Riddle Aeronautical University.

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**Randy NYMAN**

Has 23 years of range safety experience and has supported toxic dispersion model development and analysis applications at the United States federal ranges. He contributed to the development of toxic hazard and risk screening methodologies adopted by the FAA for US commercial spaceport licensing applications.

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**Ron NOOMEN**

Received his M.Sc. degree in 1983 with honors in aerospace engineering from Delft University of Technology, in The Netherlands. He analyzed satellite laser ranging data until 2006 and was the analysis coordinator of the International Laser Ranging Service from 1998 to 2006. Currently, he is an assistant professor at Delft University of Technology, coaching interplanetary optimization student projects.

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Has worked for over 30 years at Sandia National Laboratories in national security, nuclear energy, and environmental programs. He has made key contributions in aerospace systems, space nuclear power and propulsion, terrestrial nuclear power, and nuclear materials management. He received a Ph.D. from the University of Texas.

**Sandrine RICHARD**

Environmental expert since 2005 at CNES/French Guiana Space Centre. Manages the measurement campaign for launchers in flight, the launch range activities and industrial activities. She is in charge of sustaining ISO 14001 certification with an environmental management plan, and research activities for knowledge of impacts, projects of waste reductions and energy consumption mitigation. Ph.D. in chemistry and environmental science.

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**Joseph A. SHOLTIS**

LtCol, USAF (Ret) was system program manager (1970–93). Owner, Sholtis Engineering & Safety, 1993–Present. He managed SP-100 space reactor program (1983–87). Participated in every US nuclear-powered space mission since 1974: Viking I & II, Lincoln Experimental Satellites 8 & 9, Voyager I & II, Galileo, Ulysses, Mars Pathfinder, Cassini, Mars Exploration Rovers A & B, Pluto – New Horizons, and Mars Science Laboratory.

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**Carlos E. SOARES**

BS in aerospace and ocean engineering from the Virginia Polytechnic Institute and State University, and an MS in aerospace and mechanical engineering from the University of Oklahoma. He has worked 22 years at Boeing Research and Technology in molecular contamination, plume effects and space environment effects. He is currently the Boeing Lead Engineer/Scientist for ISS External Contamination in the Space Environments Team.

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**Richard G. STERN**

Mr. Richard G. Stern was Department Director of the Flight Mechanics Department at The Aerospace Corporation for 23 years. Mr. Stern joined The Aerospace Corporation after working at Space Technology Laboratories (Ramo Wooldridge) and

Northrop Aircraft. Mr. Stern is the author of numerous technical papers and the co-holder of a patent for a passive satellite attitude control system.

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### **Marc TOUSSAINT**

Joined the European Space Agency (ESA) in 1986, after several years spent in the Belgian industry. He has covered many functions and responsibilities on different ESA programs, including Columbus module for the International Space Station and Ariane 5 launcher. He was responsible for the Ariane 5GS version and is currently working on Ariane 5ME version.

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### **Jean-Pierre TRINCHERO**

Senior range safety expert of the Centre National d'Etudes Spatiales (CNES) at the Europe's spaceport in French Guiana in the fields of pyrotechnics and propulsion, chemical propellants and payloads preparation. He held operational responsibilities as payload safety officer, head of range safety (ground and flight) including operational responsibility for flight termination system (FTS). He has been also deeply involved in developing launchers safety policy in Europe.

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### **Jérôme VILA**

Joined the Centre National d'Etudes Spatiales (CNES) Launcher Directorate in 1997. He covered different positions throughout Ariane 5 design and development phase, finally leading the overall project from 2005 to 2009. Since 2009, he has been Technical Officer for the Ariane 5 Midlife Evolution launcher. He holds a Master's degree in engineering from Ecole Centrale de Paris, France.

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Distinguished member of technical staff at Sandia National Laboratories. He led the Power Systems Working Group for the Mars Science Laboratory Interagency Nuclear Safety Review Panel, and was member for the Pluto New Horizons mission. He is Fellow of the International Association for the Advancement of Space Safety (IAASS).





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