

SPACE PROGRAM MANAGEMENT

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Marcello Spagnulo • Rick Fleeter

with

Mauro Balduccini • Federico Nasini

Space Program Management

Methods and Tools



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Marcello Spagnulo
Rick Fleeter
Mauro Balduccini
Federico Nasini

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Dedication

*Non est ad astra mollis e terris via
(It is not easy the way for the stars)
Seneca, from Hercules Furens*

*Thanks to Daniela and Claudia for making
brighter my way for the stars
Marcello Spagnulo*

Foreword

What is a major project or program? The construction of an international gas pipeline, the development and commercial launch of a new type of aircraft for transporting passengers, the building of the tunnel under the English Channel between France and England, the planning and building of a nuclear power plant, the on-ground manufacturing of the components of the International Space Station and their launch and assembly in space are all examples of major programs.

All of these achievements were made possible through enormous investments in research and development and major industrial programs that have very distinct features: major financial investment and long-term time commitment, cutting edge innovation, international partnerships, and ever-increasing levels of technological risk.

Space programs, by their very nature, are part of the scientific and industrial activities we have just illustrated.

Space programs therefore require huge investments and it falls upon governments, through their space programs, to provide the funding for their realization. Private businesses can only begin to invest in space systems when an application from a space program becomes commonly used and is valuable to a large market.

This particular feature of the space sector, in addition to creating a barrier to competition, requires public investors to be fully aware of their country's scientific and industrial strategies and to synthesize these scientific, industrial, and political aspects.

These considerations are even more important in international cooperation, where national interests must co-exist with compromises resulting from political negotiations, which prevail over technological or scientific issues.

The decision-making process involved in a space program is therefore complex and varied: the national space agency plays a crucial role in protecting and enhancing both previous as well as future national investments.

Once it has been decided to start up a space program, proper management becomes crucial and can be summarized in two key factors: cost management and time management.

The essence of management therefore lies in the ability to plan, control, and intervene in the development of the project to maintain time schedules and costs established at the program's start-up.

This capability involves two things: from the industrial viewpoint, it is the capability of managing production properly (in accordance with the time schedule and costs established in the contract), and from the agency's viewpoint, as the capability of knowing how to invest through proper planning.

If the first aspect is easily identifiable (industrial management), the second one is not so easy to recognize, but has an enormous impact on program management.

It involves the agency's ability to plan and invest in time schedules and proper modalities, which are consistent with national and international strategies and which do not impede or anticipate scientific or industrial activities that could cause imbalances in public expenditures.

These imbalances can generate surpluses or liabilities that affect the agency's management, which has the responsibility of investing in long-term and highly strategic programs.

Here is where space program management not only involves proper management methods and tools, but also *governance* of the space sector for planning and strategic guidance of public investment.

Based on these brief considerations, the space sector is unique and the management of space programs is a very complex task. In the past, the sector's decision-making and management processes were a reference model for other industrial sectors because of their distinctive technological and development nature.

The methods and tools dealt with in this book aim at drawing the reader closer to the specific nature of this sector. It illustrates how the conception, management, financing, and start-up of a space program are among the most complex of human activities and how space history has influenced today's programs.

It is an area where highly qualified, specialized men and women are an essential and crucial prerequisite.

President of the Italian Space Agency ASI

Enrico Saggese

Preface

I had the privilege of returning, to the International Space Station (ISS) for the third time from 16 May to 1 June 2011 after the “Marco Polo” mission in 2002 and the “Eneide” mission in 2005. This time I did not go with the Russian Soyuz spacecraft, but I flew on board the Space Shuttle Endeavour, which took off from the hot, sunny Cape Canaveral launch base in Florida.

I spent 16 incredible days on board the Endeavour and the ISS, experiencing events and surroundings I had known years before, which were always new, fascinating, and captivating.

Sixteen work days that were the result of years and years of work, training, and testing; in other words planning and preparation.

This is why reading and writing a preface for a book which concerns space programs, after experiencing them first-hand, evokes a strange feeling in me.

After having experienced a certain kind of training for many years, made up of methodically planned intense activity and having spent many days on board the ISS, I am now reading behind-the-scenes activities and methods with a mixture of curiosity, interest, and reflection.

Space, as a sector, is continuously evolving and becoming a work environment open to everyone. It provides an opportunity for growth and development; however, the absolute methodological and management rigor that has always characterized it has remained a constant.

During incredible days of intense activity inside the ISS in orbit at a speed of 28,000 km/h around our planet, you are not aware of all the work that has gone into those times. However, you only have to reflect for an instant to understand how much of what only a few people have the privilege of experiencing is the result of the work of thousands of men and women who for years have planned, realized, and managed a network of programs and projects to make the largest house in space.

The subject of space program management, especially where the human factor figures, is therefore so complex and varied that even an astronaut (the very person who incarnates the essence of the reason men and women design spacecraft or orbiting stations) is unaware of the whole picture.

This is why reading a book which examines several of the vital mechanisms of the three sides of “technological-management-financial development” helps us to better understand how this fascinating and complex world works, a world where a few hundred space objects in orbit around the Earth help us every day to understand the climate, to communicate with each other, to locate, and help us to live in space to explore and experiment new ways of propelling human life beyond the frontiers of the Earth itself.

We now have the “experience” of how to live in space, thanks to planning and management logic that was completely unknown until a few decades ago. The inductive principle has become essential for extrapolating general rules from the individual cases of prior experiences in order to create standards of reference for new and innovative programs that drive man ever further into the universe.

In this sense, I consider it a duty to thank the author of this book. He is a personal friend of mine whose clarity of thought and ability to analyze and synthesize have translated into the passion evident in this book.

A passion, which is for us all and for the future generation of scientists, engineers, astronauts, and human beings in general, the source of curiosity and knowledge.

Pilot of the Italian Air Force
Astronaut of the European Space Agency ESA

Roberto Vittori

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- Mr. Mauro Balduccini wrote Chap. 6.
- Mr. Federico Nasini wrote Chap. 7.
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- Mr. David J. Goldstein wrote Sect. 9.2 of Chap. 9.
- Mrs. Pat Remias wrote Sect. 9.3 of Chap. 9.

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All the authors and contributors declare that the topics discussed in this book are based entirely on personal experience and in no way involve the agencies or companies where they are employed.

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Introduction

Space missions are one of humankind's activities in which the ambitious goals achieved—the putting into orbit of the first satellite, human spaceflight, application programs for telecommunications and remote sensing, the Moon landing, the assembly of the great orbiting space station—have had to co-exist with the development of technologies, the challenges of innovation and research, available resources, organizational competences, the ability to manage risks and costs and to maintain time schedules with the expected margins.

This difficult synthesis of ambition and realization, vision and real workability have characterized all the greatest undertakings, in all fields of human endeavor, and regardless of the motivations of an economic, social, military, scientific, humanitarian, or cultural nature which prompted them, the factors which characterize great undertakings and which make them viable are recurrent elements.

Space activities, however, embody the measure of great human missions more than any other and still strike our imagination, while they are here with us on a daily basis. All we have to do is think of the great International Space Station to have immediate confirmation of the feasibility and concreteness of a success that seems to reaffirm itself each day.

Marcello Spagnulo, the author of this book on space programs, offers to the reader a complete overview of the factors which make up a space mission, an activity which, just like all great undertakings, has always been very complex, rich with challenges and risks, time schedules and considerable costs which are often very uncertain.

The book richly details and expresses the specific nature of the space sector starting with an overview of these developments in various countries. It illustrates historical developments at length and the outlook of the space market. In this way the author more or less implicitly defines the reasons for which man decided to propel himself into space and the objectives of the space missions that were carried out.

One chapter is dedicated to program management, an activity in which the author, because of his experience in his rich and varied career, has acquired his expertise directly. The description of management proposed in this book therefore enriches a systematic description of this subject with the vision of experience. Program management is the first of the major factors necessary for developing every great mission, especially space programs. The book examines its essential aspects, dedicating great detail to specific areas, such as the management of configuration (of great importance also in the related field of aeronautics) and the management of delays, an issue that is of strong current interest to all complex industrial programs.

Space missions carry high levels of risk. The book pays particular attention in detailing technical and financial “reliability and security” issues and the insurance market for space programs.

The management of costs and financial issues brings the book to a close with two chapters devoted to subjects which are usually ignored in space education courses, but

which are of increasing importance for future space programs. Cost is an increasingly critical factor in missions and in the development, implementation, and management of space systems. This criticality, linked to various factors but relevant both for space industries funded by government agencies and for space companies working in the market, has transformed cost from a factor of program management to a factor in mission planning.

Paradoxically, financial issues will bring about more innovation. The future of many space industries in the development phase will be linked to the ability to implement financing that involves public–private types of partnership for developing and implementing programs.

It is a well-organized and complete book, and not difficult to read, even for readers who have not come across space issues during their university studies or professional experience.

This is an important feature for a book on space programs. In fact, in as much as technology and science certainly play a determining role for the implementation and success of every space mission, space is not just a world of engineers and scientists. The professions involved in each space program cover a very broad spectrum ranging from economics to management, legal issues to financial ones, political to military and security issues, and life sciences to medicine.

Marcello Spagnulo's book provides the world of users, who only encounter the space world at a certain point of their career, with an instrument for understanding the world of space programs and for an in-depth examination of the various issues.

Because of its organization, complexity, and completeness, the book can also be used as a tool for an in-depth study of the themes examined to benefit technical experts—scientists and engineers—who because of their involvement in a problem, can sometimes lose sight of the overall picture when they encounter elements outside the technological realm.

Marcello Spagnulo's involvement in the educational community of the Master's program in satellites and orbiting platforms of the University of Rome "La Sapienza" (where he obtained his degree in Aeronautical Engineering) is related to his desire and effort to conceive and realize such a rich and complete book.

During my teaching experience and in defining the scope and didactic contents of the Master's degree in satellites, I had the good fortune to meet many professionals, such as the author of this book, who wanted to pass on their experience to new generations and to other professionals who wanted to update their professional abilities and enter the world of space. As is well known, the University of Rome "La Sapienza" was the cradle of Italian space activities and it is perhaps for this reason that an operational and application component has always been present in our cultural tradition alongside academics and research.

Today this tradition allows us to develop research and development programs in various space venues in intense synergy with the world of space agencies, companies, and institutions that are involved in space in various ways. High-level training in space systems and missions put the academic community in close contact with various organizations that develop and operate space programs.

For these courses, Marcello Spagnulo's book will be a precious tool in the years to come for the cultural and professional development of those who wish to become involved in space missions of the future.

Paolo Gaudenzi

Full Professor of "Aerospace systems and design" at the University of Rome "La Sapienza"

Director of the Master's program in Satellites and Orbiting Platforms and
Coordinator of the Research Doctorate in Aeronautic and Space Technologies

Introduction by the Author

When I published in 2011 the Italian version of this book I choose as cover a photo from NASA website which always has been in my mind as an icon.

The image I'm talking about was taken on 21 July 1969 from the porthole of the command module "Columbia" of Apollo 11. It shows the lunar module "Eagle" which stands out from the surface of the moon after having landed on it only 24 h earlier. On board the lunar module are the first of two human beings who landed on a celestial body outside of Earth for the first time in history. And in the dark background of the photo, just behind the lunar module, a bright tiny Earth is suspended in space.

The Apollo 11 mission, through this iconic photo, represents, in my opinion, the most striking image depicting a small machine built by man which travelled in a sideral void from Moon to Earth. It signaled a high point, a peak that till today has not been scaled again by the scientific and industrial community involved in the difficult task of sending human beings or probes into orbit around the Earth or into deep space.

But the entire Apollo program was a watershed. This was not only because of its technological, political, and scientific success, but also because of its value as a conceptual and project reference.

In order to have a million pieces that made up the Apollo spacecraft function perfectly 380,000 km away from Earth, the US space agency NASA, together with industries and universities involved in the lunar program, conceived of rules and procedures that have influenced project and management modalities for all subsequent space programs.

This is why a book which attempts to illustrate several general management principles of space program management cannot help but give due credit to this human mission which continues to leave its mark on activities that see men and women in Europe, as well as in the USA, Russia, Japan, India, China, Canada, and other countries still involved in the planning and building of satellites and spacecraft.

But there is an even more personal reason for having chosen this photo as a symbolic icon.

For every engineer, who like myself, studies the basics of Astrodynamics to learn how to face the fascinating intellectual and technological challenges of our profession, one of the basic texts was the book "Fundamentals of Astrodynamics" written in 1971 by three professors, Roger Bate, Donald Mueller, and Jerry White, who worked in the Department of Astronautics of the US Air Force Academy.

This book had that same photo on its cover.

I had a copy of the book in 1981 by an engineer at NASA's Goddard Space Center, whom I will never cease to thank for his part in helping me understand our world a little better.

Rome, January 25th 2011

Marcello Spagnolo

List of the Authors (and Contributors)

Marcello Spagnulo

Rick Fleeter

Mauro Balduccini

Federico Nasini

David J. Goldstein

Pat Remias

Ronald Schertler

Frank Gargione

Richard Gedney

