

Electric Propulsion in Germany: System activities today, institutions involved, challenges coming up

IEPC-2013-257

*Presented at the 33rd International Electric Propulsion Conference,
The George Washington University • Washington, D.C. • USA
October 6 – 10, 2013*

Norbert Püttmann¹ and Klaus Ruf²
*German Aerospace Center (DLR) – Space Administration,
Koenigswinterer Str. 522-524, D-53227 Bonn, Germany*

Abstract: DLR Space Administration is supporting research and development of new technologies for Electric Propulsion (EP) at companies and universities in Germany on behalf of the Federal Ministry of Economics and Technology (BMWi). The development of EP has started in Germany in 1960, the support of sponsorship by the Federal Ministry of Education and Research (BMBF) in 1964. During the past years a profound infrastructure containing research, development and education has been evolved to make possible cutting edge technologies for electric thrusters, their subsystems, diagnoses and modeling. These technologies lower the cost of commercial and institutional satellites and enable scientific missions, which have requirements hardly to be fulfilled by other propulsion. More than 200 satellites driven and controlled by different types of EP are in space today, launched by different countries for dedicated applications.

Nomenclature

EP	=	Electric Propulsion
DLR	=	German Aerospace Center
BMWi	=	Federal Ministry of Economics and Technology
BMBF	=	Federal Ministry of Education and Research
HEMP-T	=	High Efficiency Multistage Plasma Thruster
ARTES	=	Advanced Research in Telecommunication Satellites – an ESA Programme
PSCU	=	Power and Supply Control Unit
FCU	=	Flow Control Unit
RIT	=	Radio Frequency Ion Thruster
TED	=	Thales Electron Devices
HTA	=	HEMP Thruster Assembly
PIC	=	Particle in Cell Code

¹ Head Systems for Satellites, General Technologies and Robotics, norbert.puettmann@dlr.de

² Project Manager HEMP-TIS, General Technologies and Robotics, klaus.ruf@dlr.de

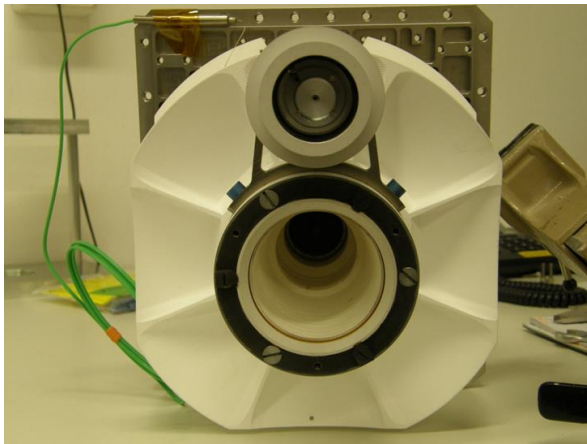
I. Introduction

More than 200 satellites driven and controlled by different types of EP are in space today, launched by different countries for dedicated applications. These technologies lower the cost of commercial and institutional satellites and enable scientific missions, which have requirements hardly to be fulfilled by other propulsion.

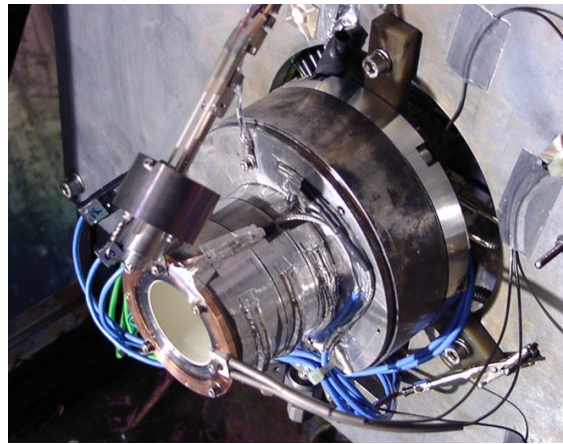
DLR Space Administration is supporting research and development of new technologies for EP at companies and universities in Germany on behalf of the Federal Ministry of Economics and Technology (BMWi). The development of EP has started in Germany in 1960. The Federal Ministry of Education and Research (BMBF) supported those activities by sponsorships since 1964. During the past years a profound infrastructure containing research, development and education has been evolved to make possible cutting edge technologies for electric thrusters, their subsystems, diagnoses and modeling. But – more flight heritage is requested.

II. Present activities concerning thrusters

During the past six years a lot of effort was invested in the research, development and qualification of the “High Efficiency Multistage Plasma Thruster” (HEMP-T) to be flown on the Small-GEO mission in the frame of ESA’s ARTES 11 Programme for telecommunication satellites. Research and feasibility studies started already in 1997 to investigate the abilities of this new technology.



HEMP thruster today



HEMP 3050 BB

Courtesy of THALES Electron Devices, Ulm, Germany

In the end of a research and development timeframe of nearly 15 years, supported by the DLR Space administration, and the preparation of the HTA (HEMP Thruster Assembly) during the past 6 years the hard- and software is facing the qualification procedures for the SGEO mission, which are going to start soon.

The assembly contains 4 thrusters, a Power supply and control unit (PSCU), a Flow control unit (FCU), harness and tubing. Nearly 7.200 hours of continuous thrust and 9.800 on-off cycles have to be proved for a lifetime of 15 years. A consumption of approx. 85 kg of xenon gas is foreseen for the mission. The HEMP thrusters could be candidates for missions that require higher thrust levels and longer lifetime.

III. RIT thrusters

The RIT technology (Radio Frequency Ion Thruster) has been developed at the University of Gießen by Prof. Löb. Astrium Lampoldshausen has continued with the research, development and refinement of this technology.

Astrium's first Radio-frequency Ion Thruster Assembly (RITA) was successfully demonstrated in space aboard ESA's European Retrievable Carrier EURECA. A RITA-10 propulsion system shifted ESA's ARTEMIS spacecraft into GEO after a launch failure.

A strategic partnership between EADS and the Russian Company EDB Fakel concerning RIT technology was signed. RIT's are planned for scientific missions.



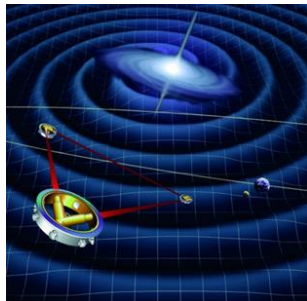
RIT – Thruster examples
courtesy of University of Gießen



RIT-10 (white) and a British Kaufman- thruster UK-10 on ARTEMIS
Courtesy of EADS

IV. μ N-RIT thrusters

The University of Giessen is cooperating with EADS astrium in Lampoldshausen, Germany, to develop the μ N-RIT thruster for tiny thrusts for scientific missions with support of DLR Space Administration



LISA (Laser Interferometer
Space Antenna)



μ N-RIT during test
courtesy of University of Gießen

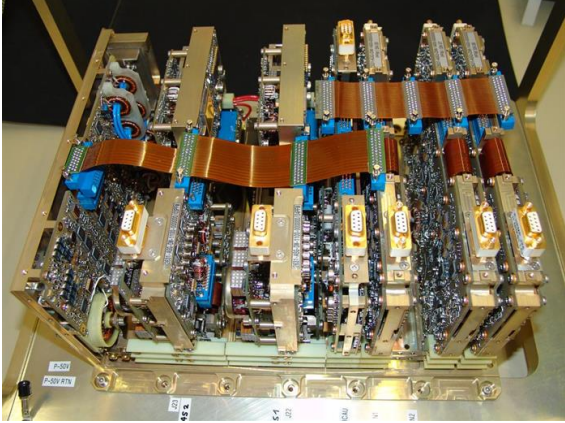
One example for a mission requiring tiny thrust could be the LISA (Laser Interferometer Space Antenna) mission in the ESA Science Programme to detect and observe gravitational waves; with Ion drives to orbit and μ N thrusters for attitude control. In this case three satellites will be arranged in a triangle with a distance of approx. 5 Mio km. the Orbit would be behind the earth in a distance of approx. 50 Mio km. The accuracy needed would be in the area of 20 Picometer (10^{-12} m) that means 1 part in 10^{20} .

This technology enables Spin offs like surface treatment, e.a.

V. Research and development of subsystems

To operate electric thrusters some subsystems are required. Research and development of subsystems needed for electric propulsion systems were supported by DLR Space Administration in parallel.

An important subsystem for EP is the provision of electric power. DLR has supported the development of a generic high power supply and control unit. This technology has been adapted to the HEMP thruster equipment.

	
HEMP PSCU für SGEO- Plattform	10 PSCU PFM at incoming inspection

Key Facts:

- Input Voltage: standard regulated telecom bus, (50V on SGEO)
- Fixed Output (Anode Voltage 1 kV) 2x HVPS modules 1 kV each, 1.4 kW for Anode Supply
- Max. efficiency 96%
- FPGA-based controller
- Operation by Macro or Micro –Commanding
- 4x Neutralizer Supply & Flow Control
- Current measurement on floating HV-Lines

Power supplies for RIT and μ N-RIT have been developed by EADS Friedrichshafen as well.

VI. Provision of test facilities and diagnostic tools and their development

In Germany test facilities and diagnostic tools are available for different purposes like research, testing and qualification. The newest test facility was established by DLR at the Research institute in Göttingen, Germany, capable for qualification testing of a wide range of EP.

The development and research of the HEMP thrusters were made possible with the test facility at TED company in ULM, Germany.

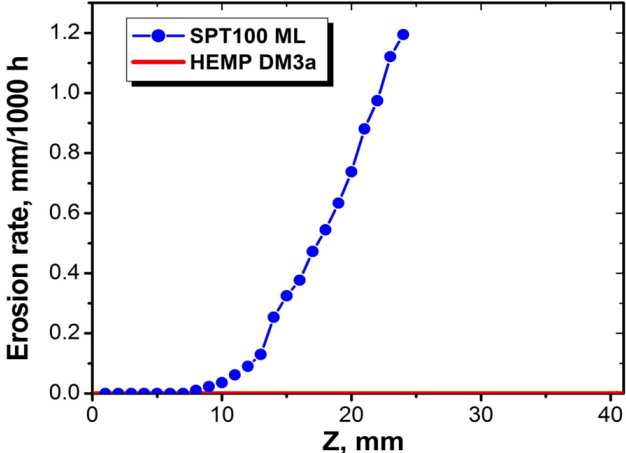
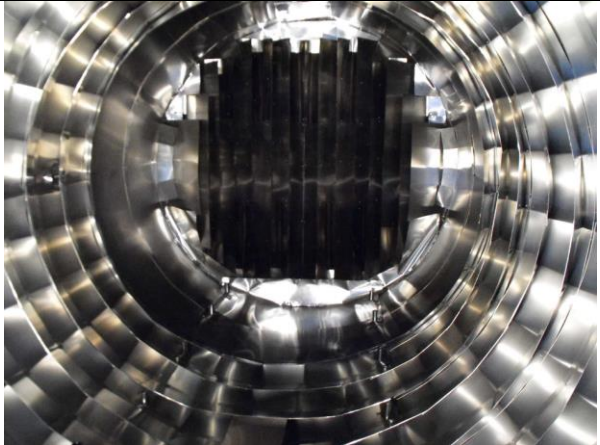
	
DLR High Vacuum Test Facility STG-ET Cooperation with JLU Gießen	Courtesy of Thales Electron Devices, Ulm, Germany

General Horizontal axis chamber with single door design 169 mounting ports Engine stand with probe holder decoupled from vacuum chamber		Test facility at TED, Ulm Chamber diameter 2.4 m Chamber length 4.75 m Chamber volume 20 m ³ Rough vacuum pumps 250 m ³ /h Turbo molecular pumps 2x 2,000/l/s	
Data Length of vacuum chamber 12.2 m Diameter of vacuum chamber 5 m Volume 236 m ³ No-load Pressure $2 \cdot 10^{-6}$ mbar (only with turbo pumps) Evacuation time 2-3 hours (empty chamber)			
Engine EP Engine Power Range Up to 25kW input power (current limitation due to target cooling)			
DLR High Vacuum Test Facility STG-ET Cooperation with JLU Gießen		Courtesy of Thales Electron Devices, Ulm, Germany	

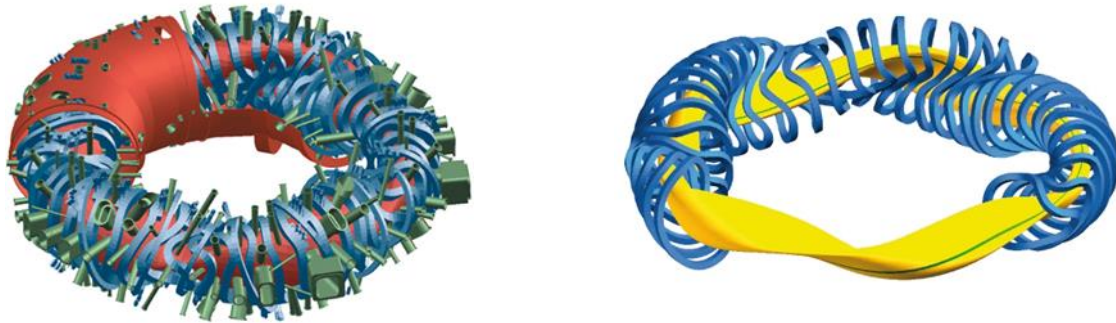
VII. Research and application of computational tools for the prediction of plasma

A cooperation between DLR, TED (Thales Electron Devices) and IPP (Max Planck Institute for Plasma Physics in Greifswald, Germany) has been established to compute and predict the behavior of plasma in electric thrusters like HEMP and its mutual reaction with walls, using Particle in Cell Codes (PIC). The results of the cooperation are outstanding, the HEMP- thrusters and the test facility for validation could be improved

„Simulation of particles for Ion engines for space flight“ is a project for development, validation and application of a modular built particle- in- cell- code (PIC) for the simulation of the generation of plasma in electric thrusters and for the investigation of plasma-wall- interaction.

			
Erosion simulation courtesy of TED		Aluminum covered internal volume of vacuum chamber courtesy of TED and Aerospazio, Sienna, Italy	

The application of the codes is based on calculations for a fusion reactor.



Results of computation for a fusion reactor, courtesy of Max-Planck institute for plasma physics

VIII. Research and establishment of scientific education for electric propulsion

At different universities in Germany the research and development of EP using different types of thrust generation and subsystems for many levels of thrust have been established. At Gießen university a course of studies for plasma physicists specialized for electric thrusters has been established, cooperating with research institutes of DLR in Göttingen, Germany.

Different types of micro propulsion are under research as well.

IX. New challenges coming up

During the council on ministerial level in 2012 the ARTES 33 Programme was decided, in which the new project Elektra will support European satellite industry in developing, launching and validating in-orbit a full electric-propulsion telecommunications satellite in the 3-tonne launch mass range. Such a capacity does not yet exist in Europe.

This would enable electric propulsion for orbiting telecommunication satellites instead of chemical propulsion and would result in 90% savings in propellant and therefore more payload capacity or a smaller launcher.

X. conclusion

The electric propulsion technology containing thrusters developed in Germany, their adaptable subsystems, test facilities equipped with newest abilities, possibilities for computation of plasma generation and interaction would be outstanding candidates for Elektra, for better missions, commercial business plans, cost savings and future improvements even more, when proven in orbit as soon as possible.