5th International Workshop on Verification and Testing of Space Systems

Секция 1

СТАНДАРТЫ ВЕРИФИКАЦИИ И ИСПЫТАНИЙ

Нормативно-техническое обеспечение проведения испытаний и верификации в ракетно-космической промышленности России: текущее состояние и гармонизация с международными принципами и стандартами. Наземная отработка десантного модуля КА «ЭкзоМарс-2018»

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Турин, Италия, 17-19 мая 2016 г.

5th International Workshop on Verification and Testing of Space Systems

Session 1

VERIFICATION AND TESTING STANDARDS

Regulatory and Technical Base for Testing and Verification in the Russian Space Industry: State of the Art and Harmonization Requirements According to International Principles and Standards. ExoMars - 18DM Case Study

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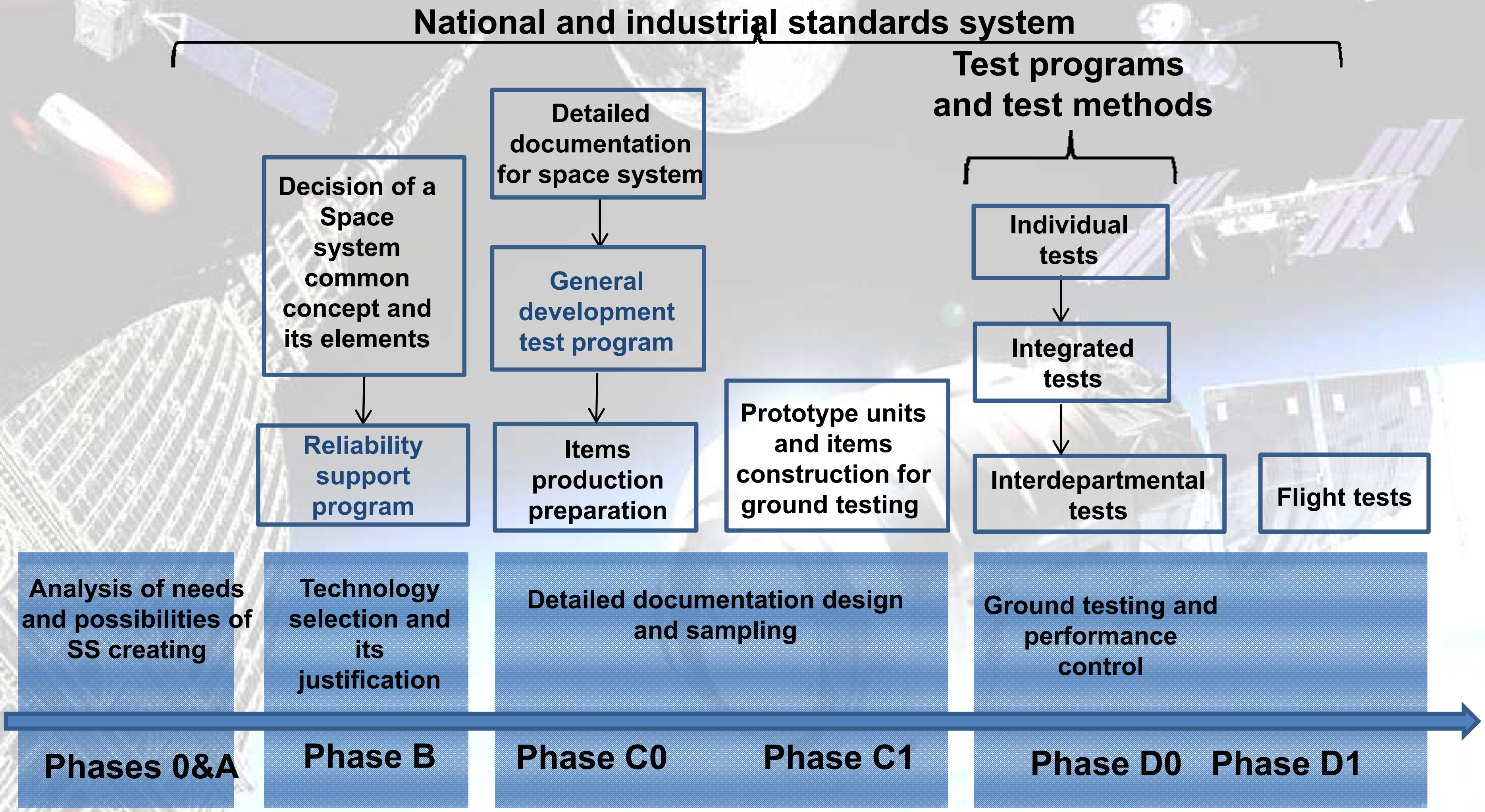
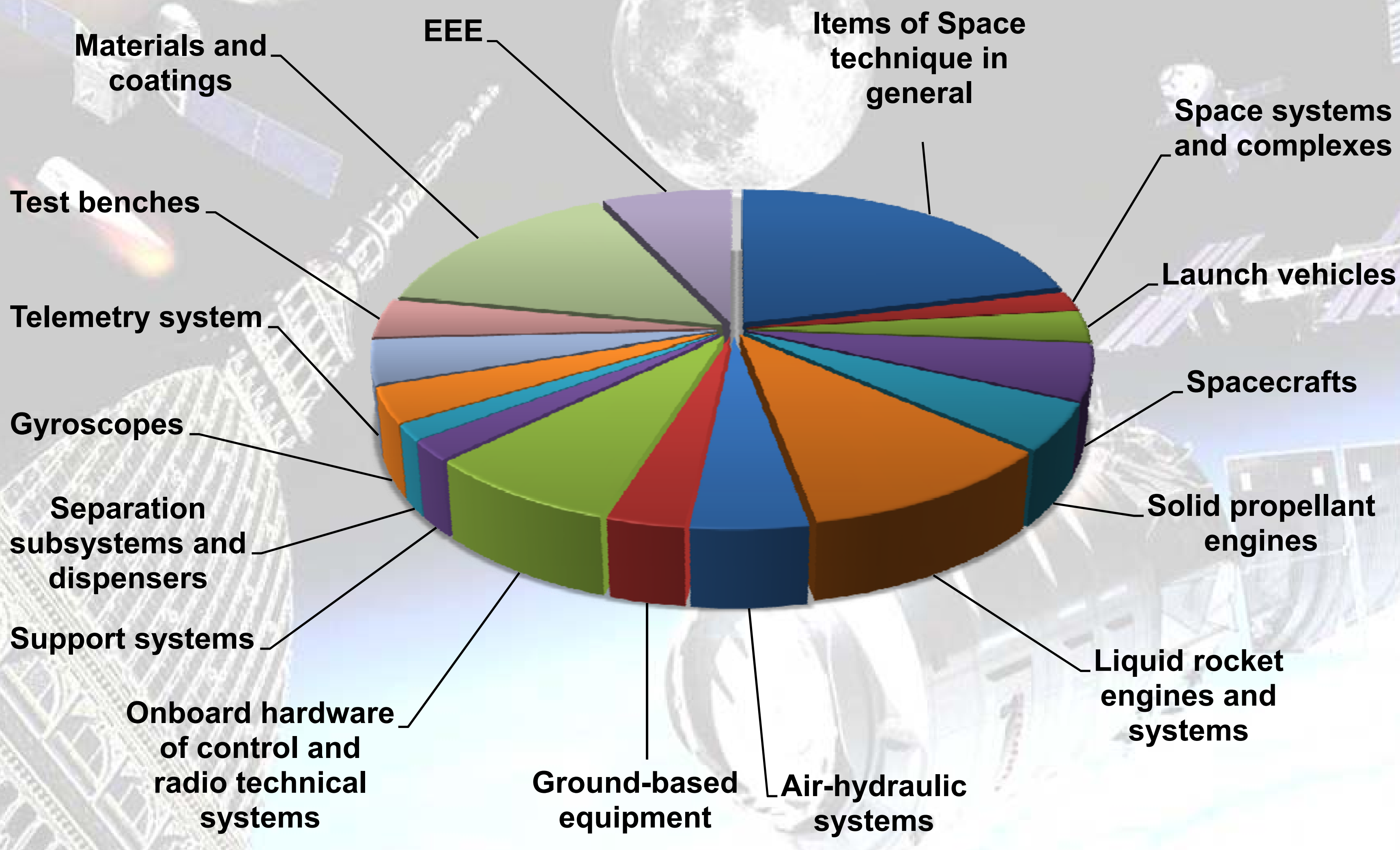
Torino, Italy, May 17-19, 2016

Standard technical assurance of space testing in Russia



Russian Federation Testing Standards



Harmonization of Russian and ISO Verification & Testing Standards

- Published ISO documents (PL – Russia):
  - ISO 24917 «Space systems. General testing requirements for launch vehicles»;
  - ISO 15860 «Space systems. Gas contamination. Measurement methods for full-scale tests»;
  - ISO 16694 «Space systems. Expandable liquid rocket engines. The measured parameters list at on-ground firing and flight tests of LRE»;
  - ISO TR 17400 «Space systems. Launch and integration site general test requirements»;
  - ISO TR 18147 «Space environment (natural and artificial). The method of the solar energetic proton fluencies and peak fluxes determination».
- Projects under development (PL – Russia):
  - ISO FDIS 17851 «Space systems. Space environment simulation for material tests. General principles and criteria»;
  - ISO FDIS 17540 «Space systems. Liquid rocket engines and test bench. Terms and definitions».
- 17 Russian national standards (GOST R ISO), which set requirements to Space Systems testing and verification, are identical to ISO.

ECSS and Russian standards harmonization

An agreement with ECSS about translation and quotation of ECSS Standards and Handbooks was signed by Federal Agency on Technical Regulation and Metrology of the Russian Federation (Rosstandart) on 24 February 2015.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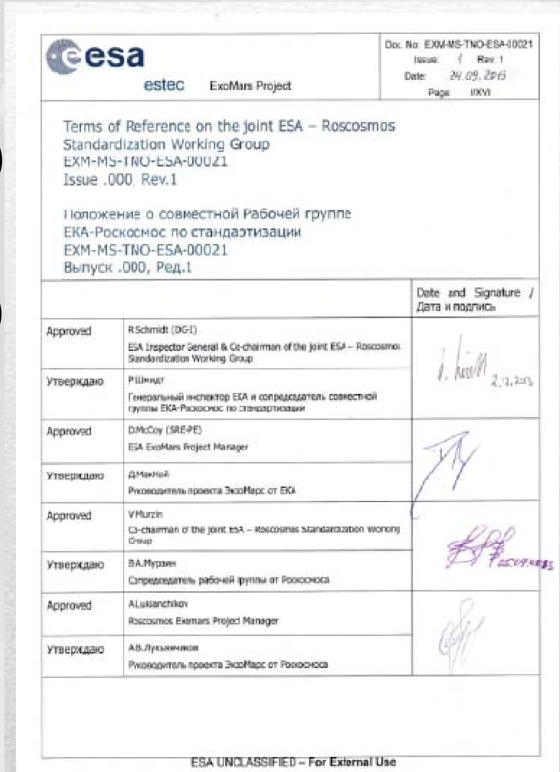
In accordance with the agreement, ESA, in the name of the ECSS members, grants the Federal Agency on Technical Regulation and Metrology of the Russian Federation (Rosstandart) the rights to quote, to translate and to incorporate parts or in whole the ECSS Standards and Handbooks into the national standards of Russian Federation.

Joint ESA – Roscosmos ExoMars 2018 Standardization Working Group (WG)

ESA part:

Rudolf Schmidt, (DG-I, co-chair)
Giovanni Colangelo (DG-IC)
Rafael Bureo Dacal (TEC-MSS)
Jean-Loup Terraillion (TEC-SWE)
Roger Jegou (TEC-QR)
James Godfrey (ESOC)
Daniel Firre (ESOC)
Rene Pischel (EMO)

+ European enterprises



esa estec ExoMars Project

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Terms of Reference on the joint ESA – Roscosmos Standardization Working Group
EXM-MS-TNO-ESA-00021
Issue .000, Rev.1

Положение о совместной Рабочей группе ЕКА-Роскосмос по стандартизации
EXM-MS-TNO-ESA-00021
Выпуск .000, Ред.1

		Date and Signature / Дата и подпись
Approved	R.Schmidt (DG-I) ESA Inspector General & Co-chairman of the joint ESA – Roscosmos Standardization Working Group	
Утверждаю	Р.Шмидт Генеральный инспектор ЕКА и сопредседатель совместной группы ЕКА-Роскосмос по стандартизации	
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Утверждаю	[illegible] Руководитель проекта ЭкзоМарс от ЕКА	
Approved	V.Murzin Co-chairman of the joint ESA – Roscosmos Standardization Working Group	
Утверждаю	В.А.Мурзин Сопредседатель рабочей группы от Роскосмоса	
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+ 10 Russian enterprises

WG purpose - to develop and advice in coordination with the project teams of Roscosmos and ESA joint solutions for the application of requirements of Russian standards and ESA standards in the framework of the Exomars 2018 mission

Compatibility matrix of Russian Standards to ECSS-E-ST-10-03A "Space engineering. Testing" standards' requirements (1/2)

ESA requirement	Compatibility of standards' requirements of ESA and Russia (compatible / partially /not compatible)
4.1 Testing philosophy	Compatible
4.2 Model philosophy	Compatible
4.3 Development testing	Compatible
4.4 Qualification testing	Compatible
4.5 Acceptance testing	Compatible
4.6, 7 Protoflight testing	Present methodology is not applied
4.7 Retesting	Compatible
4.8 Test conditions and tolerances Qualification test levels and durations Static/acceleration 1,25, 100 s + 50 s per Mission,	Partial compatibility. Loading level can reach 1, 5 or more, of safety factor. Test duration can reach some minutes on operating level of loading. Test duration is specified by required time of the parameter measurement on peak level.
4.9. Operations validation testing	Compatible
4.10 Test data	Compatible

Compatibility matrix of Russian Standards to ECSS-E-ST-10-03A "Space engineering. Testing" standards' requirements (2/2)

ESA requirement	Compatibility of standards' requirements of ESA and Russia (compatibility / partial /no compatibility)
4.11 Test documentation	Compatible
5.1 Equipment test requirements 5.1.19 Microgravity environment compatibility test, equipment qualification	Compatible. Special test is not regulated by normative regulations. Environment conditions should be considered during certain aspects of tests performance.
5.2 Subsystem test requirements	Compatible
5.3 Element test requirements	Compatible
5.4 System qualification test	There are no specific analogues.
6.1 Equipment test requirements	Partial compatible. General requirements are defined by wide range of regulations in Russian rocket-and-space industry. Sub-requirements are indicated in programs and tests methodologies, developed on the base of normative regulations, proceeding from technical requirements for the item
8 Pre-launch testing	Partial compatible. Testing is conducted in accordance with developed instructions for performance of work on facilities

Compatibility matrix of Russian Standards to ECSS-E-ST-10-02A “Space engineering. Verification” standards’ requirements (1/2)

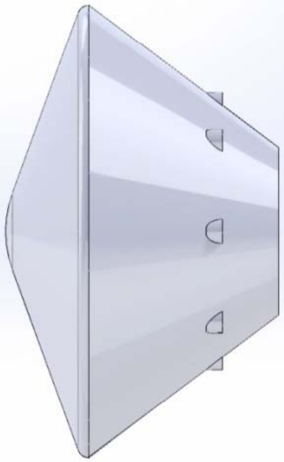
ESA requirement	Compatibility of standards’ requirements of ESA and Russia (compatibility / partial /no compatibility)
4 Verification process	
4.1 Verification objectives	Compatible
4.2 Verification process logic	Compatible
4.3 Verification methods	Compatible
4.4 Verification levels	Partial compatible. In Russian Standards another principle of breakdown on levels is accepted. It takes into account entry of components of a product into the general structure (i.e. SC as a whole and his main components can't be at one level as it is accepted in the ExoMars project.
4.5 Verification stages	Compatible

Compatibility matrix of Russian Standards to ECSS-E-ST-10-02A "Space engineering. Verification" standards' requirements (2/2)

ESA requirement	Compatibility of standards' requirements of ESA and Russia (compatibility / partial /no compatibility)
5 Verification strategy 5.1 Requirements classification 5.2 Selection of methods, levels and stages of verification 5.3 Selection of models 5.4 Verification by test 5.5 Verification by analysis 5.6 Verification by Review-of-design 5.7 Verification by inspection	Compatible
6 Verification implementation 6.1 Verification Control Board 6.2 Verification planning 6.3 Verification tools 6.4 Verification execution and control 6.5 Verification documentation	Compatible

ExoMars-18 DM aerodynamics characterization

Steady aerodynamic characteristics



Balances

D = 23 mm
L = 207 mm

Test model M 1:51

Model in the U-3M facility

Test program

Test No.	Facility	M_∞	α Deg.	q_∞ kg/cm²	P_o kg/cm²	p_∞ kg/cm²	$Re_{\infty Dm}*10^6$
3z231	U-3M	0,519	-6° ÷ +18°	0,111	0,704	0,586	0,52
3z232		0,907	-6° ÷ +18°	0,26	0,77	0,452	0,798
3z233		1,201	-6° ÷ +18°	0,368	0,884	0,364	0,973
3z236		1,593	-6° ÷ +18°	0,508	1,203	0,286	1,29
3z235		1,828	-6° ÷ +18°	0,593	1,521	0,253	1,52
3z234		2,047	-6° ÷ +18°	0,599	1,719	0,204	1,61
3z237		2,463	-6° ÷ +18°	0,586	2,225	0,138	1,65
4z63	U-4M	2,963	-6° ÷ +18°	0,532	3,011	0,087	1,75
4z62		3,449	-6° ÷ +18°	0,538	4,584	0,065	2,08
4z61		4,027	-6° ÷ +18°	0,436	6,046	0,038	2,06

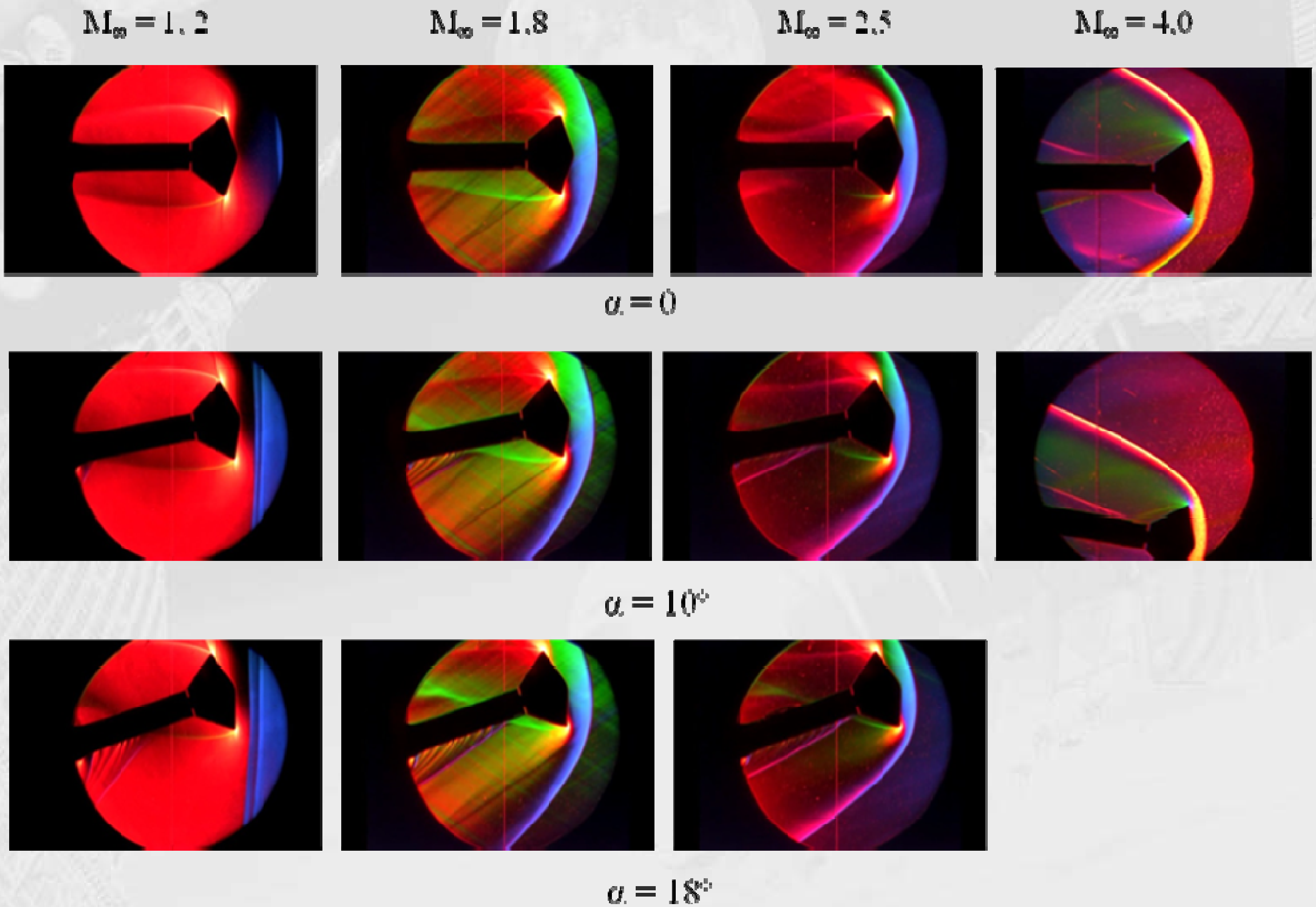
α = -6°, -4°, -3°, -2°, -1°, 0, 1°, 2°, 3°, 4°, 6°, 8°, 10 °, 12 °, 14 °, 16 °, 18°

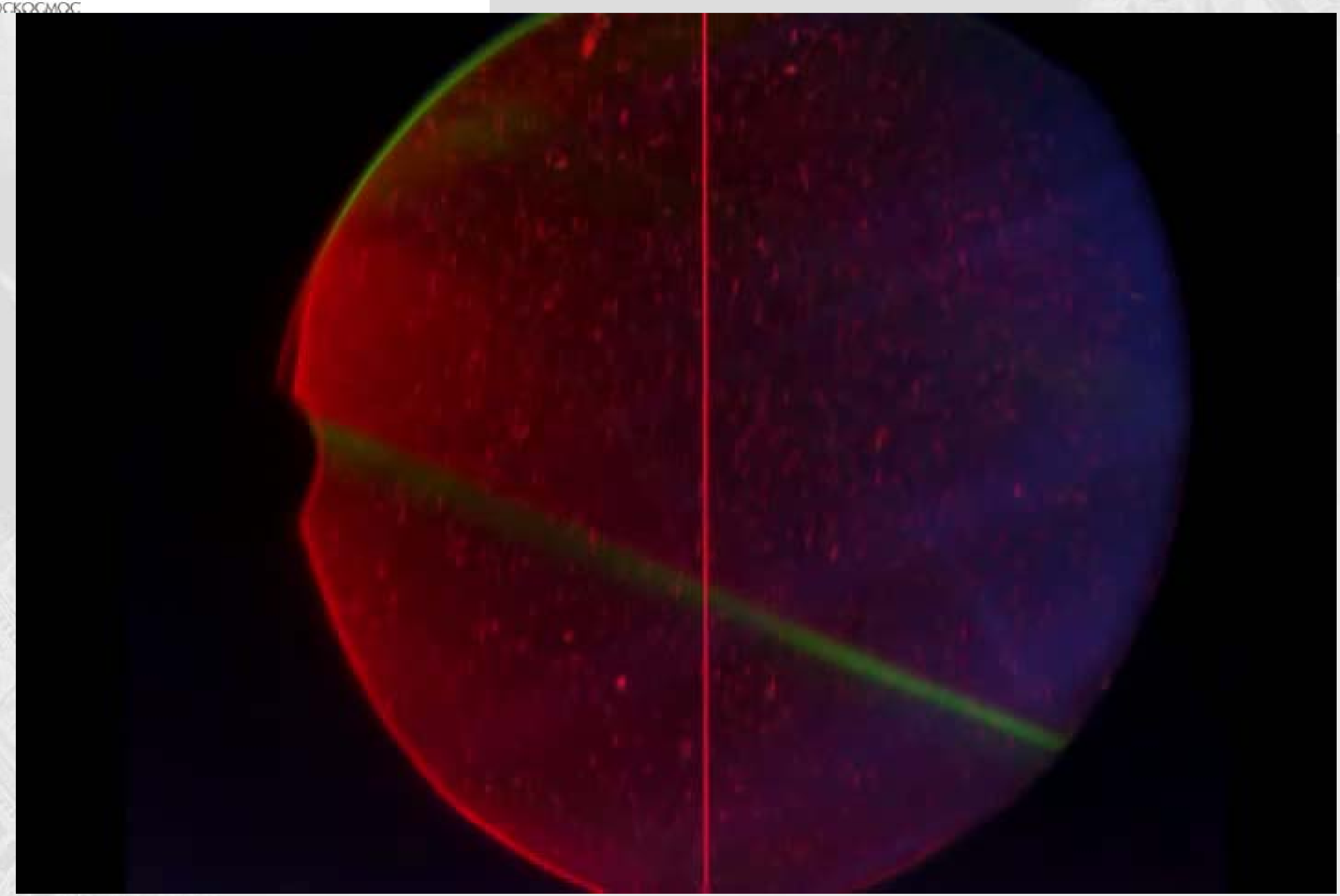
ADC specified: C_x, C_y, m_{zo}

Relative meansquare error:

$\sigma C_x/C_x$ = (2-3)%, $\sigma C_y/C_y = \sigma m_z/m_z$ = (2-2.5)%.

Model flow shadowgraphs





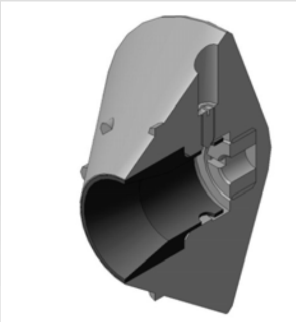
Unsteady (dumping) ADC

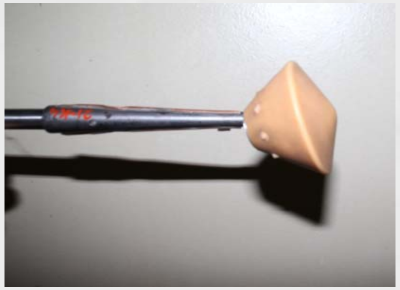
Test program

$\alpha = 0 - 13°$

M_∞	0,52	0,8	1,2	1,58	1,79	1,97	2,45	3,03	3,53	4,05
$Re_{\infty D} \cdot 10^{-5}$	4,106	4,301	5,029	6,018	3,619	2,917	4,937	3.37	2.84	3.49
q_∞, КПа	8,06	11,94	17,55	22,35	13,51	10,714	16,69	6,58	6,58	9,42

3D-printed DM-18 dynamic model

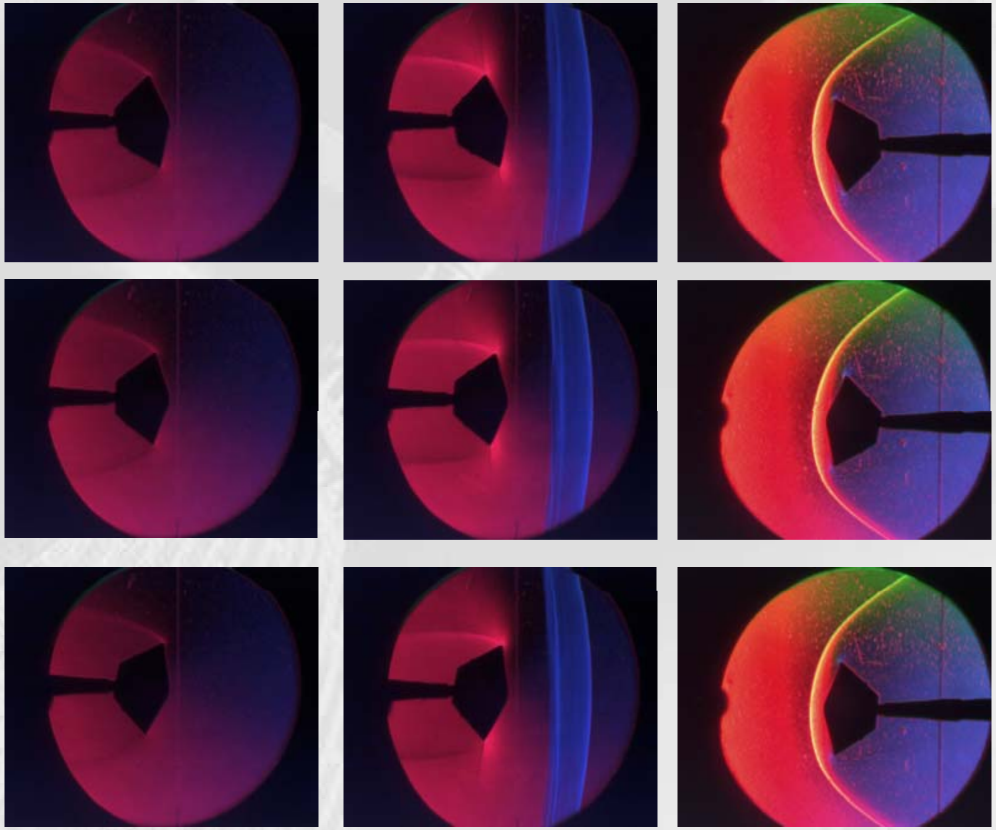




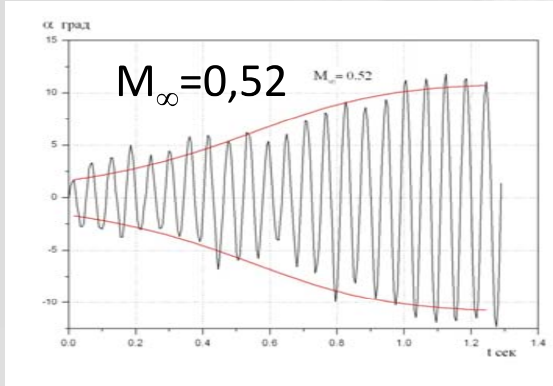
Free oscillation assembly

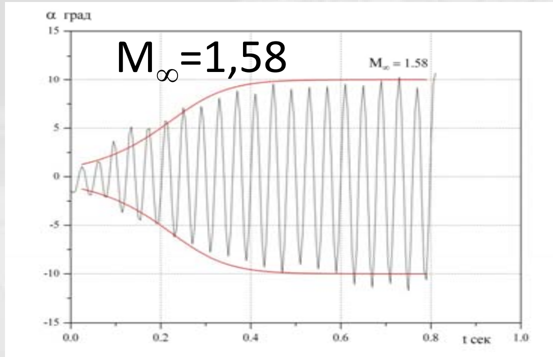
Test results on dumping characteristics

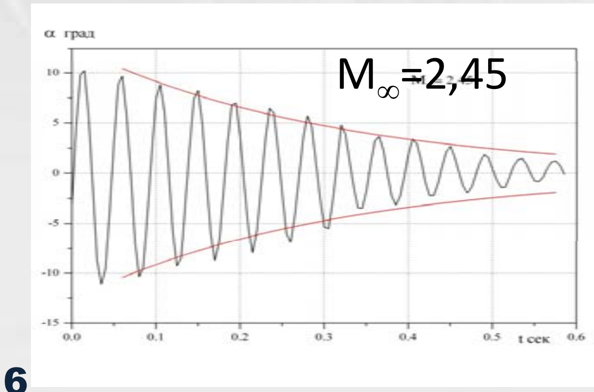
$M_{\infty}=0,52$ $M_{\infty}=1,2$ $M_{\infty}= 4,05$



Shadowgraphs of the DM unsteady flow

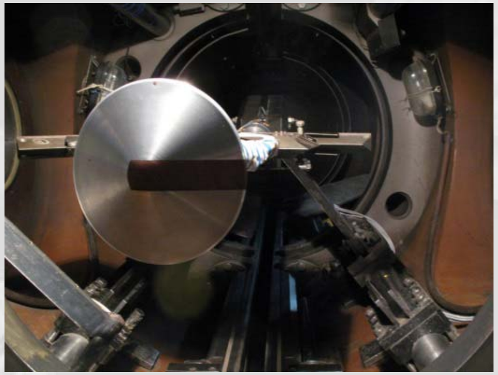




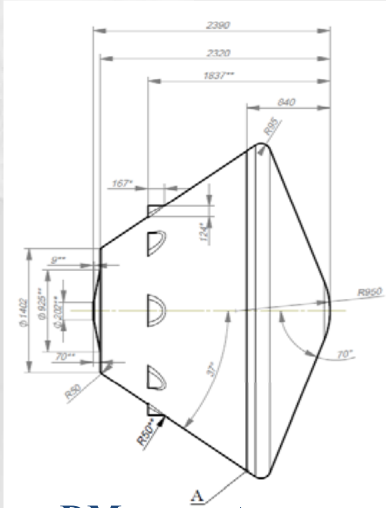


AoA vs. time for the oscillating model

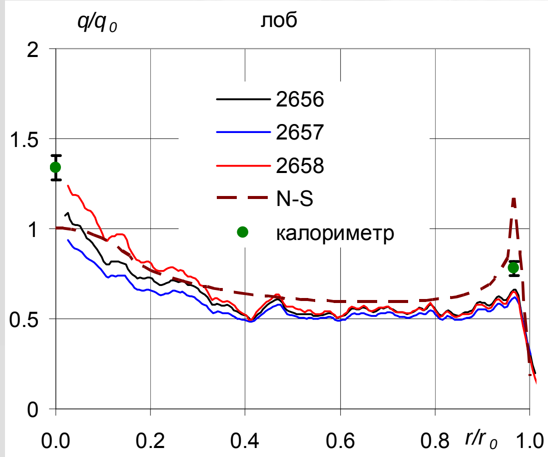
Experimental specification of thermal/frictional loads to the ExoMars-18 DM



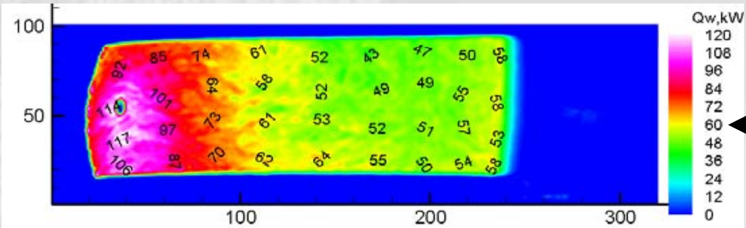
DM model in the PGU-7 test facility



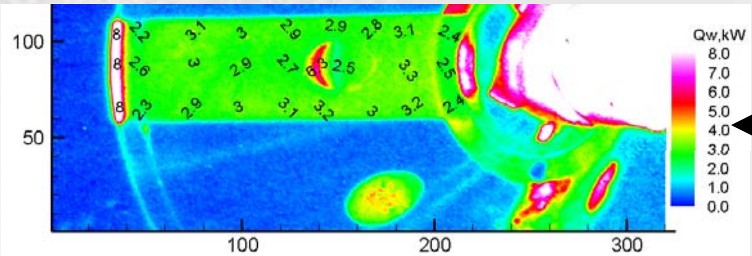
DM geometry



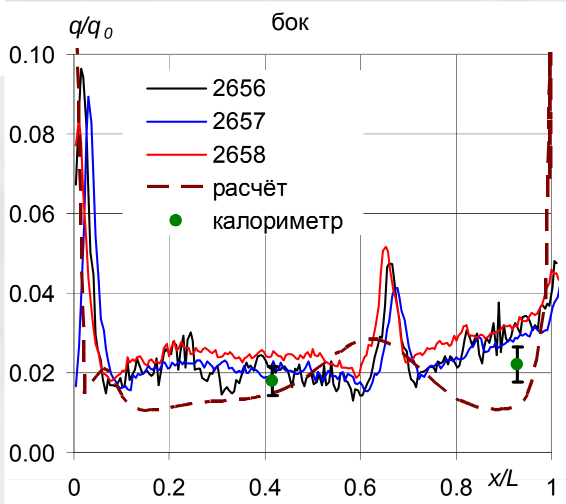
Front shield heat flux distribution (α = 0)



Heat flux distribution on the DM front surface from IR image

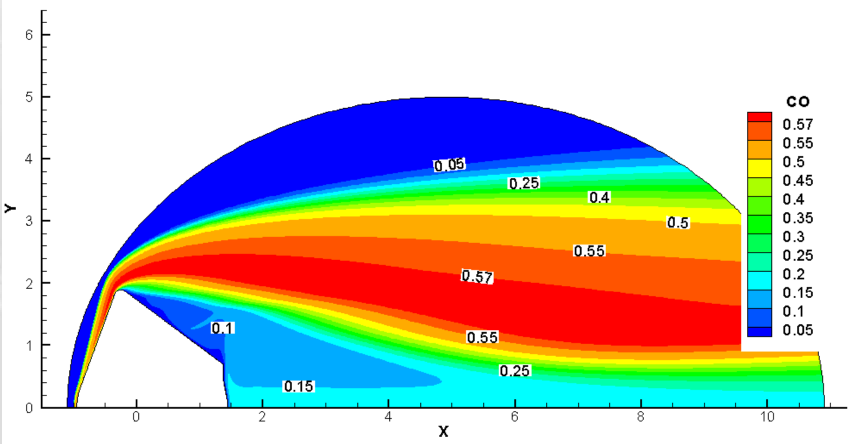


Heat flux distribution on the DM side surface from IR image

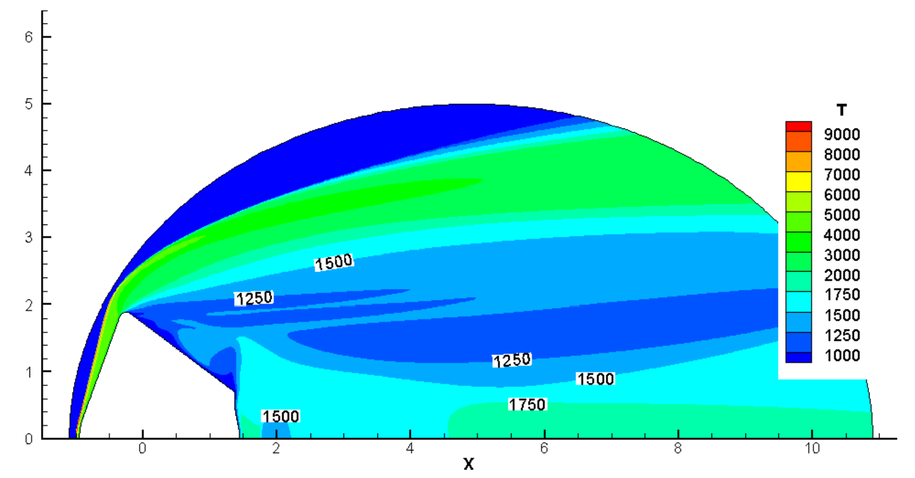


Side surface heat flux distribution (α = 0)

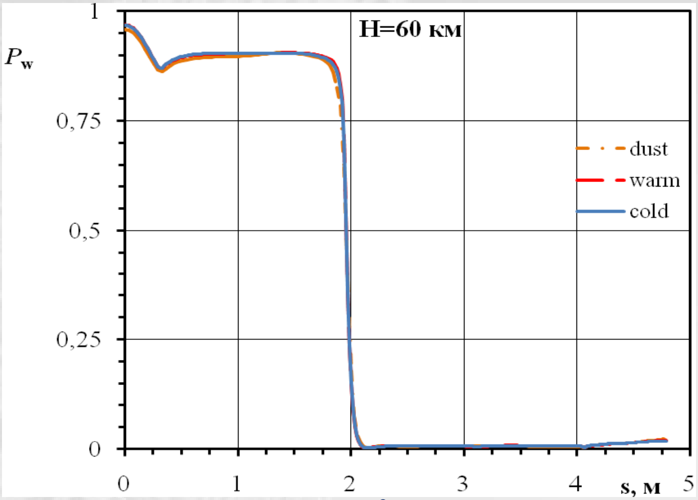
CFD modeling of thermal/frictional loads to the ExoMars-18 DM



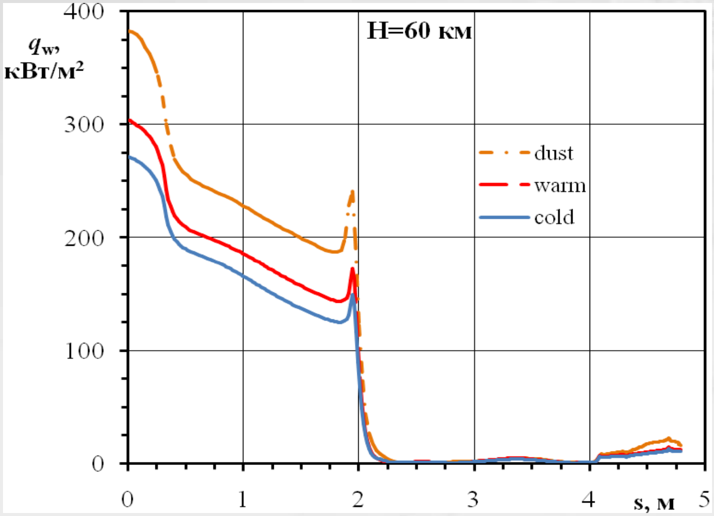
CO mass fraction field around the DM, *H*=60 km. Entry angle of 10.5°, cold Martian atmosphere



Temperature field around the DM, *H*=60 km. Entry angle of 10.5°, cold Martian atmosphere



Pressure ($P/(\rho_\infty V^2_\infty)$) distribution along the surface



Heat flux distribution along the surface

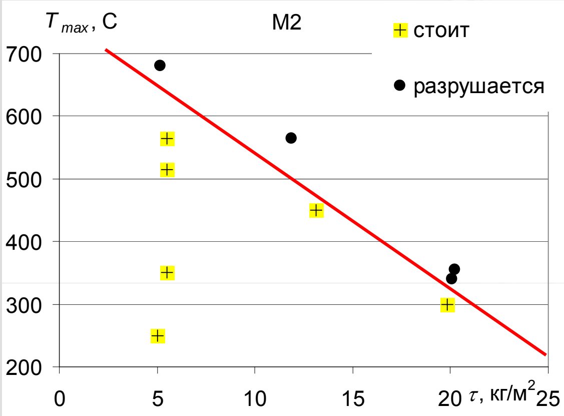
Mars atmosphere models

- Dusty
- Warm
- Cold

Tests of TPM candidates of the ExoMars-2018 mission

M2 material after a test in RF plasmatron facility in CO_2 plasma flow

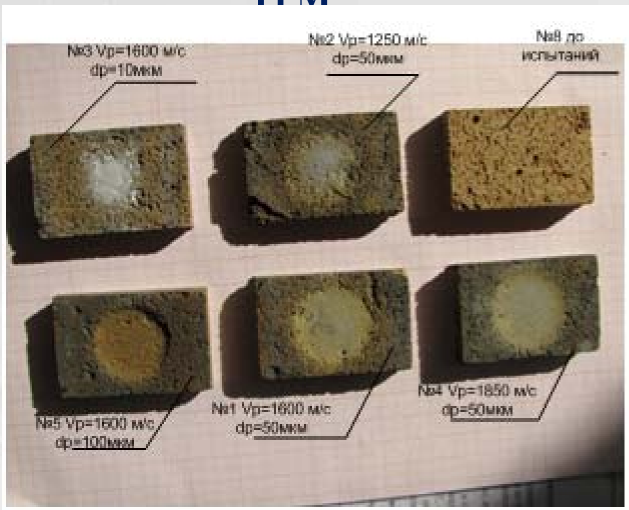
M2 material after combined thermal/skin friction action of plasma flow



Destruction diagram for M2 TPM

M7 material after a test in air plasma flow

Microscopic view to the M2 ablated surface after erosion tests



M7 material samples before and after erosion tests

Summary

The Russian Federation has formed a system of interrelated national and industrial standards in the field of space testing and verification, which is permanently updated and improved.

According to the analysis it is revealed that the Russian standards in the field of space testing and verification are harmonized with international and European standards and in generally Russian standards have more strict requirements for testing conditions than European ones.

High quality system of testing in Russia is provided by the development and implementation of the Reliability assurance programs, General development test programs, Test programs and test methods in addition to the system of standards.

Formed in the Russian Federation system of regulatory technical assurance allows to conduct ground space testing on the highest level, which is confirmed by the successful implementation of international programs.

Thanks for your attention!