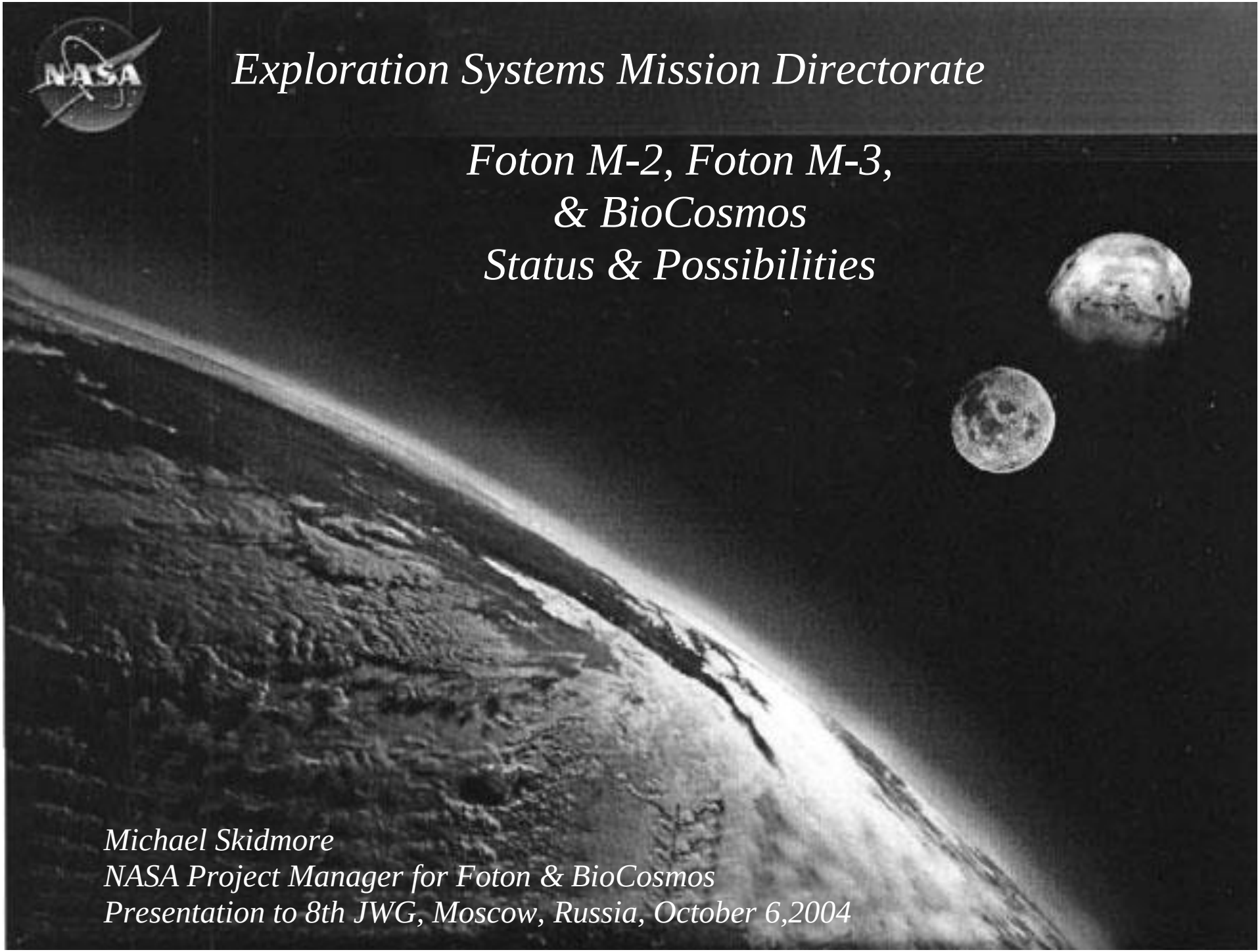


Exploration Systems Mission Directorate

Foton M-2, Foton M-3, & BioCosmos Status & Possibilities

Michael Skidmore
NASA Project Manager for Foton & BioCosmos
Presentation to 8th JWG, Moscow, Russia, October 6,2004

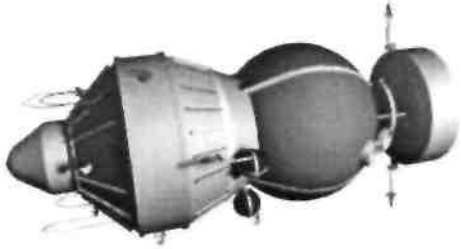
Foton M-2
Science Program
&
Progress

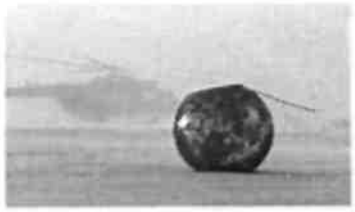
Foton M-2 Mission Overview

- Unmanned Russian spaceflight research platform
- Launch from Baikonur on modified "Vostok" in late May 2005
- Recover 16 days later in southern Russia/northern Kazakstan
- Institute of Biomedical Problems (IBMP) will fly 4 unpowered containers

- *Hemidactylus turcicus*, geckos
- *Pleurodeles waltl*, Ribbed newts
- *Procambarus cubensis*, adult fresh-water crayfish
- *Streptomyces lividans 66*, lower fungi

- US scientists invited to participate in the IMBP experiments
- ESA has purchased on-board resources





Foton M-2 Science Content

- "Receptor"
- Russian PI:Givi I. Gorgiladze
  - Institute of Biomedical Problems, Russian Academy of Sciences
- NASA PI: R. Boyle (ARC)
- Experimental object: *Procambarus cubensis*, adult fresh-water crayfish
- Experimental objectives:
  - Identify the function of the statolith receptor/afferent system during the readaptation to 1 g
  - Establish the morphological changes in the statocyst as the result of exposure to microgravity
  - Evaluate the feasibility of using implanted microelectrodes to study the receptor/afferent system in flight, including both the transitions in short-term missions and the consequences of long-term exposure to the space environment.

- Hardware Dimensions 180 x 127 x 118 mm (approx. 2.2 liters)
- Hardware Mass approx .6-.7 Kg (empty) or 1.5 Kg with experimental load

Foton M-2 Science Content

- "Plasmid"
- Russian PI: Tatiana A. Voeikova
  - Genetics Research Center
- NASA PI: B. Pyle (Montana State Univ.)
- Experimental object: *Streptomyces lividans 66*, actinobacteria
- Experimental objective:
  - Determine spaceflight effects on genetic structures
  - Identify the pattern and mechanism of genetic changes
  - Determine relationships between the changes and specific spaceflight factors

- Hardware Dimensions 180 x 127 x 118 mm (approx. 2.2 liters)
- Hardware Mass approx .6-7 Kg (empty) or 1.5 Kg with experimental load

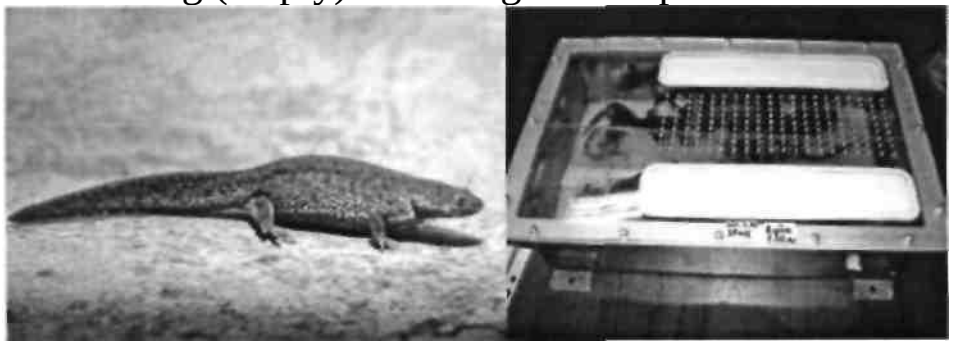
Foton M-2 Science Content

- "Gecko"
  - Russian PI: Dr. Sergei V. Savelyev
    - Institute of Human Morphology, Russian Academy of Medical Sciences
  - NASA PI: Dr. E. Almeida (ARC)
  - Experimental object: *Hemidactylus turcicus* (geckos) from the family Gekkonidae, order Sauria and class Reptilia.
  - Experiment objective: Perform histological examinations of the central nervous system, peripheral organs of senses (visual, auditory, vestibular, olfactory and vomero-nasal systems), musculoskeletal system (bones, tendons, ligaments), endocrine and reproductive systems of geckos in order to identify somatic stem cell growth and morphological tissue changes
  - Hardware Dimensions 180 x 127 x 118 mm (approx. 2.2 liters)
  - Hardware Mass approx .6-.7 Kg (empty) or 1.5 Kg with experimental load

Foton M-2 Science Content

- "Regeneration"

- Russian PI: Dr. Victor I. Mitashov
  - Koltsov Institute of Developmental Biology, Russian Academy of Sciences
- NASA PI: Dr. E. Almeida (ARC)
- Experimental object: *Pleurodeles waltl*, Ribbed newts
- Experimental objective: Determine if 16-day exposure to microgravity affects the proliferative rates of somatic stem cells responsible for tissue growth and regeneration in the newt model organism.
- Hardware Dimensions 342 x 234 x 95 mm (approx. 5.2 liters)
- Hardware Mass 1.7 Kg (empty) or 2.5 Kg with experimental load



Foton M-2 Progress to Date

- Informal discussions concerning US scientific cooperation in Russian investigations on Foton M-2 (May 2005) and Foton M-3 (September 2006) took place during the Seventh Meeting of the US/Russian Joint Working Group on Space Biomedicine, Life Support Systems and Microgravity Sciences (JWG - October 30-31, 2003) in Moscow, Russia

- On February 27, 2004 Dr. Anatoly Grigoriev, Director, RF SRC - Institute of Biomedical Problems (IMBP), Russian Academy of Sciences, sent a letter to Drs. Terri Lomax and Guy Fogleman, NASA OBPR Division Directors, inviting them to explore the possibility of US participation in the IMBP-supported biology experiments to be flown on the Russian spacecraft Foton M-2.

- In order to better understand the nature of the research opportunity on M-2 the US side requested descriptions of the science studies planned by IMBP specialists. Upon receipt of these descriptions a small group of US investigators with ongoing research that was compatible with the Russian protocols was asked to prepare proposals for review by the Office of Fundamental Space Biology (FSB). After this review a decision was taken to proceed with development activities on the proposals submitted by Dr. R. Boyle (ARC), Dr. B. Pyle (Montana State Univ, Bozeman), and Dr. E. Almeida (ARC)

Foton M-2 Progress to Date

- During an April 15, 2004 meeting (Woods Hole, MA) discussions were held concerning the possibility of US participation in four Russian biology experiments to be flown in space on the Foton M-2 mission (scheduled to launch May 31, 2005). The protocol resulting from the Woods Hole meeting specified an exchange of preliminary Experiment Management Plans (EMPs) in anticipation of a face-to-face meeting between Russian and US investigators.

- In June 2004 the US scientists mentioned above, along with the Foton M-2 management team, traveled to Moscow to meet with their counterparts. During this meeting detailed EMPs were jointly developed for each of the experiments and preliminary discussions were held concerning the nature and scope of agreements between NASA and IMBP required to conduct cooperative US/Russian experiments on the Foton M-2 mission

- An overarching Letter of Agreement (LOA) is currently in development by the international affairs offices of NASA and IMBP. This LOA will be reviewed during the 8th JWG (October 6-8, Moscow)

Foton M-3
Possibilities

FOTON M-3 Mission Overview

- Planned for 16 day flight in Fall 2006 (September/October)
- IMBP will re-fly the four experiments that were on board the M-2 mission. Anticipated enhancements include inflight manipulation / stimulation as well as inflight data collection. NASA Scientists have been invited to continue their participation in these experiments thus providing a second flight opportunity for validation studies.
  - *Hemidactylus turcicus,* geckos
  - *Pleurodeles waltl,* Ribbed newts
  - *Procambarus cubensis,* adult fresh-water crayfish
  - *Streptomyces lividans 66,* actinobacteria
- Institute of Biomedical Problems (IBMP) plans to develop a small habitat for gerbils suitable for FOTON M-3 and has made preliminary inquiries about US participation in this effort
  - Requires development of a self-contained life support system
    - FOTON does not maintain atmospheric composition
  - Gerbils chosen for ability to thrive without liquid water
    - Food must have 15 to 20% water content
- ESA has purchased on-board resources
- ESA offer to purchase mass for NASA
  - NASA focus is on *In Situ* Genetics Experiments on Nanosatellites (ISGEN, internal, ≤20 Kg)

Artificial Gravity on BioCosmos

Progress & Top Level Requirements

Artificial Gravity on BioCosmos Progress

- During a meeting at the Institute for Biomedical problems (IMBP-Moscow, June 16-23, 2004) discussions were held with IMBP scientists and specialists from TsSKB Progress (Samara, Russia) regarding the possibility of generating artificial gravity onboard BioCosmos spacecraft by either rotating the spacecraft or installing a large diameter centrifuge.
- As a follow up, NASA provided to IMBP and TsSKB a document descriptive of the top-level requirements for Exploration Research activities requiring artificial gravity as an experimental variable.
- TsSKB will discuss concepts and issues regarding generating artificial gravity on BioCosmos during this meeting

Artificial Gravity Research on BioCosmos: NASA Design Goals

- All NASA experiments will have an Exploration focus w/ multidisciplinary teams & specimen sharing
- Target Artificial Gravity levels
  - "μ G" (0.005% Earth G)
  - Moon (16.7% Earth G)
  - Mars (37.5% Earth G)
  - Earth (100% Earth G)
- Eight (or more) rodent habitats will be onboard each mission
  - Five (or more) habitats on each mission will be at "Target G"
  - Two (or more) habitats on each mission will experience minimal acceleration ("μ G" controls)
  - Spacecraft design (rotating spacecraft, on-board centrifuge, tether, ...) will determine precise level of "μ G control" acceleration
- Last pre-launch access to spacecraft between L-48 and L-24 hours
- Earliest post-recovery access to payloads between R+4 and R+6
- Telemetry downlink bandwidth sufficient to assess animal health and experimental status
  - Still images, video, environmental parameters
  - Capability to collect telemetric data from individual animals

(NOTE: these are not meant to be "hard" requirements but do reflect the general capabilities desired by NASA)

Backup
BioCosmos Hardware Capabilities

MidDeck Locker (MDL) Hardware & Other Potential NASA Hardware for BioCosmos-1

- Animal Enclosure Module
- Cell Culture Hardware
  - STL (Walter Reedl
  - CGBA [Bioserve]
  - ADvanced SEParations (ADSEP) Facility & Cassettes
  - Cell Culture Unit
- Beetle Kit Bioreactor
- Aquacell - cell culture
- IBIS-cell culture with centrifugation, refrigeration, and automated interactions
- Aquatic Research Facility (ARF)
- Other Materials Science Hardware
- And many others

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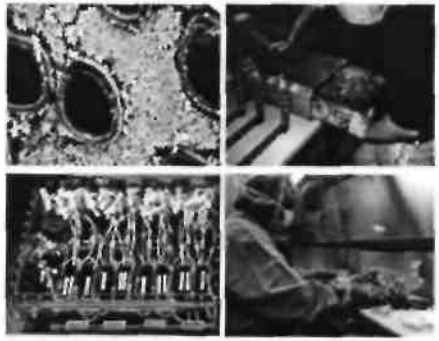
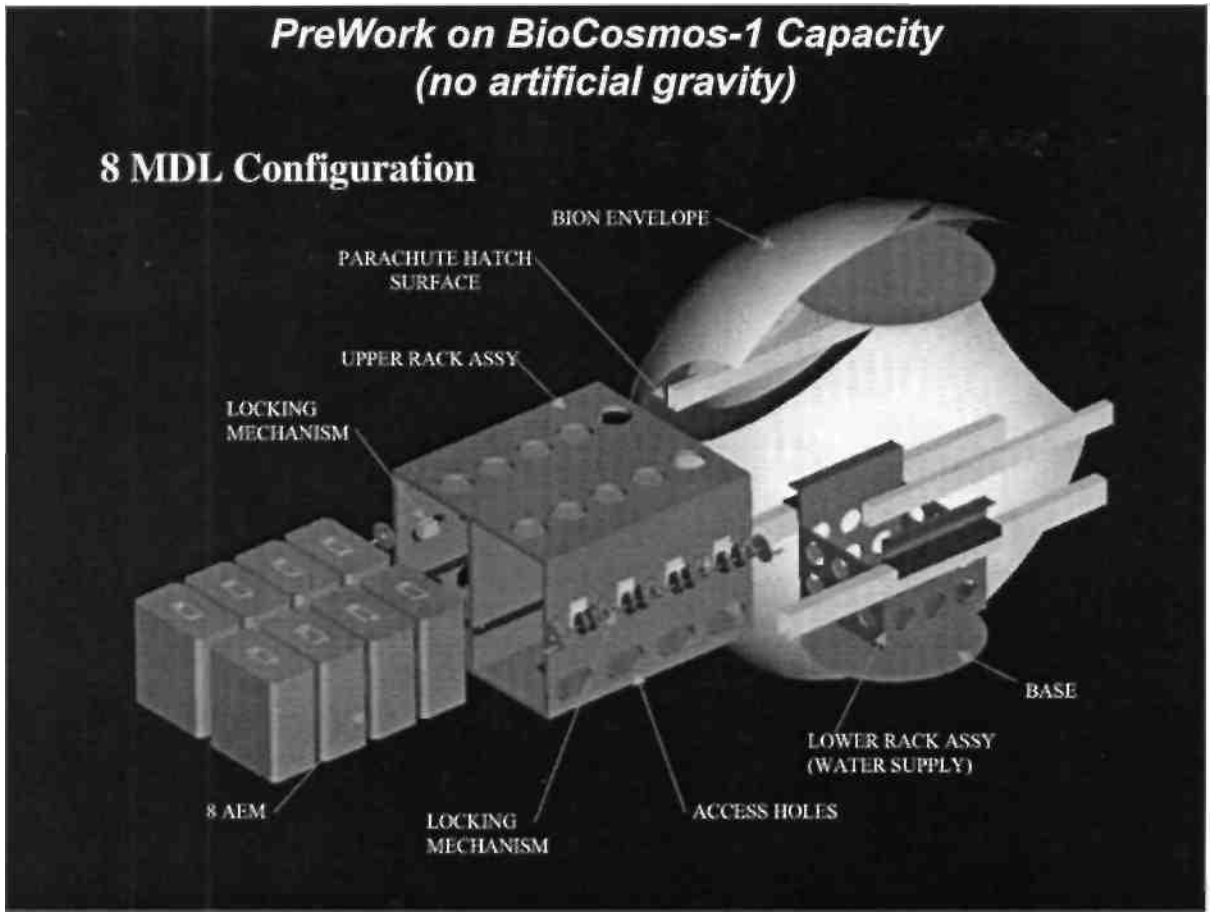
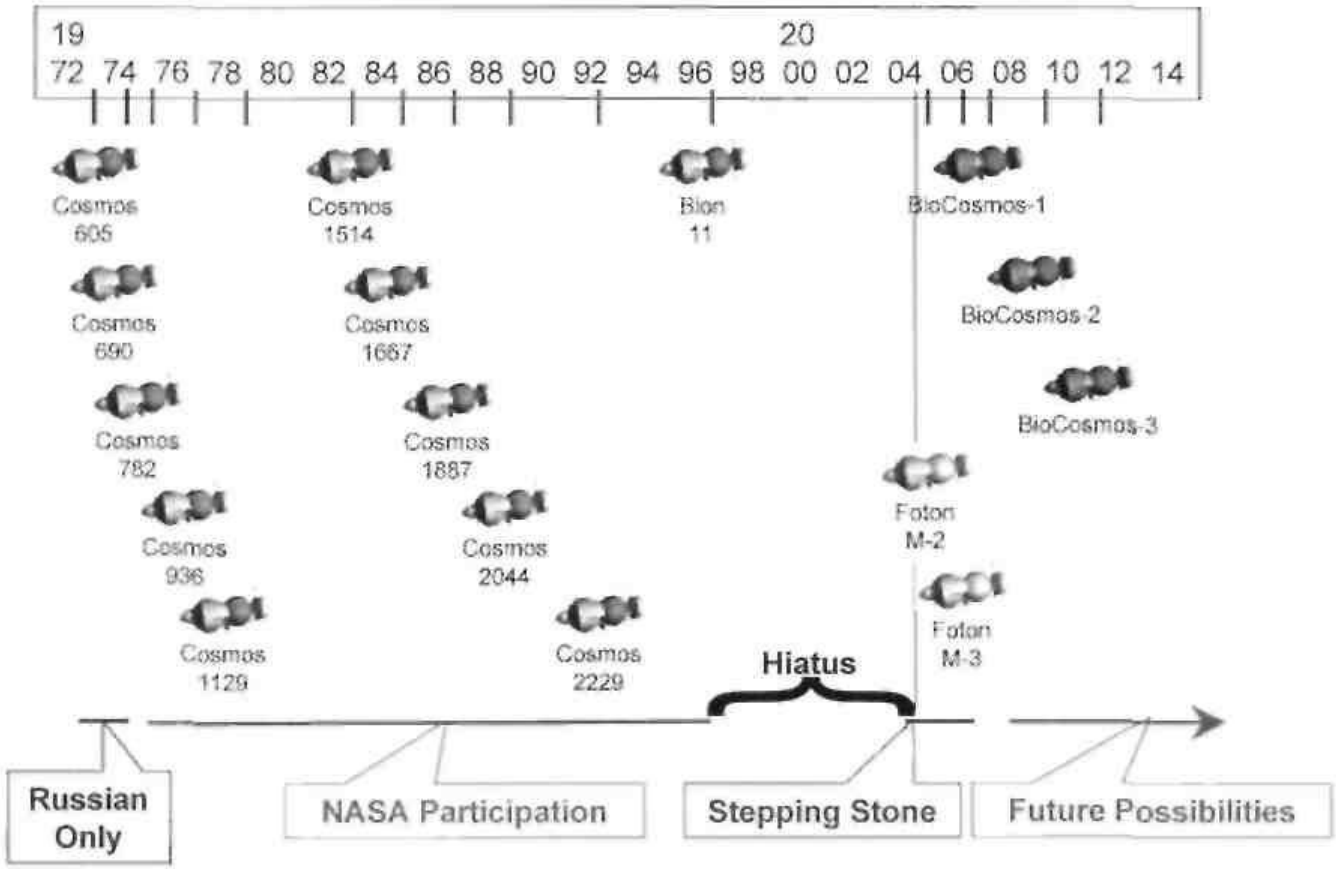
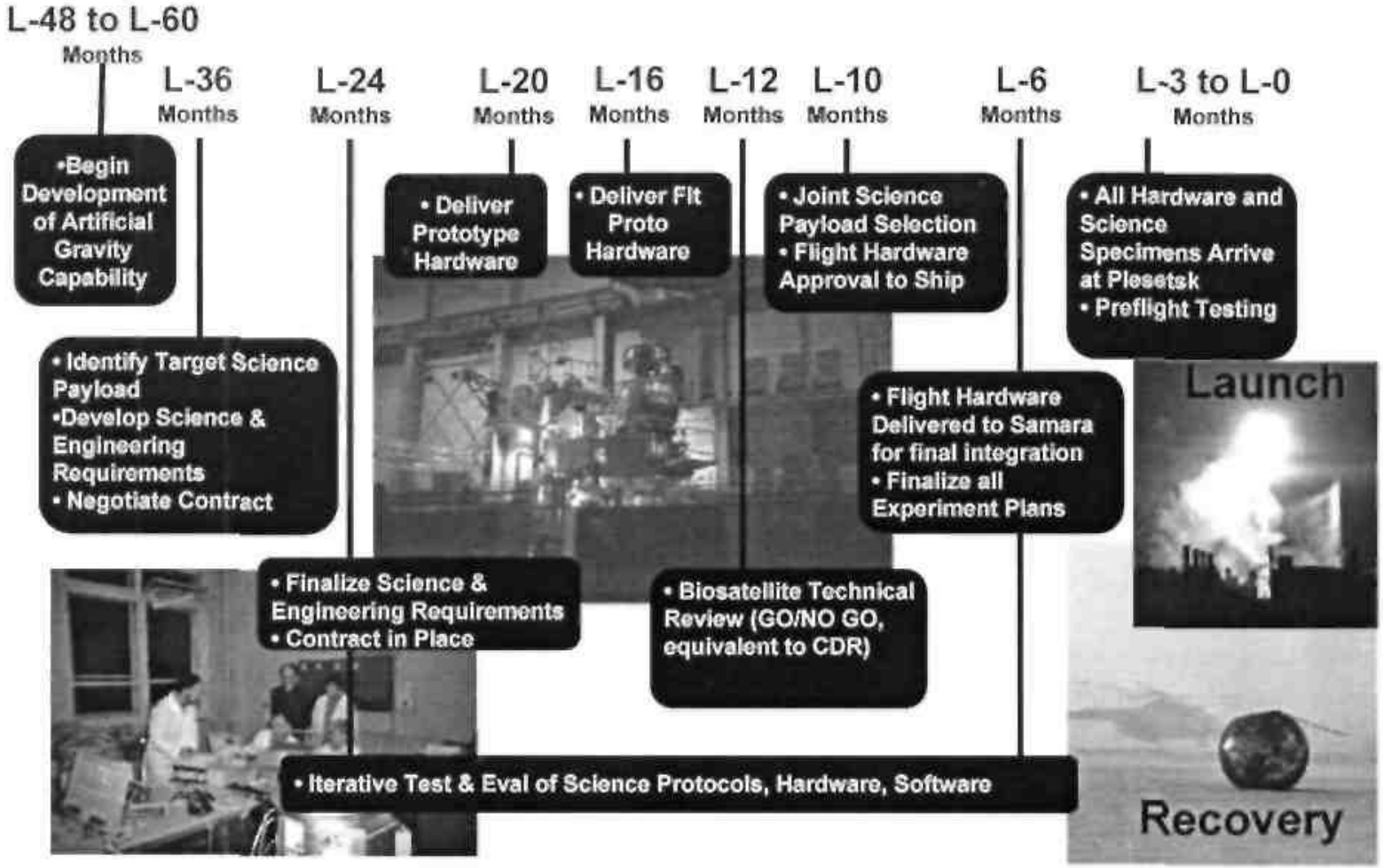



PreWork on BioCosmos-1 Capacity
(no artificial gravity)
8 MDL Configuration
BION ENVELOPE
PARACHUTE HATCH SURFACE
UPPER RACK ASSY
LOCKING MECHANISM
BASE
LOWER RACK ASSY (WATER SUPPLY)
8 AEM
LOCKING MECHANISM
ACCESS HOLES

Timeline of Russian Spaceflights with NASA Participation



BioCosmos: Estimated Hardware Development Flow



BioCosmos/Foton Operational Locations