NASA Spinoffs

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Naložba v vašo prihodnost
OPERACIJO DELNO FINANCIRA EVROPSKA UNIJA
Evropski sklad za regionalni razvoj
Kohezijski sklad
Evropski socialni sklad

Prologue
Retired space hardware

Endeavour

Prologue cont.
No more parades?!

Crew of Discovery with Sunita Williams on the way to ISS

Prologue cont.
Sic transit gloria mundi

Endeavour in dock

Prologue cont.
The new game - after Shuttle, Soyuz, and then what?!

Soyuz - rocket and module - Sunita's next transportation to ISS

Introduction

Introduction

International Space Station - beautiful home in the sky

Introduction cont.

- The source of innovation is unpredictable.
- One never knows where new knowledge of practical importance for humanity will spring forth.
- A case in point is U.S. civilian space program.
  - It was not evident from the outset that the formidable technological challenges introduced by the venture into space will generate such wide-ranging innovation here on earth.

Introduction cont.

- Space technology has been playing a key role in the qualitative transformation of the world as we know it.
- NASA spinoffs in particular have not only improved our lives but have enabled consolidation of economical, political and military dominance of the western powers across the globe.

Introduction cont.

- Going by economics alone, space exploration has been good for humanity.
- Public and private investment in U.S. civilian space program lead to thousands of spinoffs of great practical value.

Introduction cont.

- It has been estimated, that for every dollar spent on the civilian space R&D, the nation received $7 back in the corporate and personal income taxes alone.
- Besides the obvious jobs created in the aerospace industry, thousands more were created by many other companies in non-space related areas that benefit everybody.

Introduction cont.

- The largest budget allocation was in support of the Apollo program at its peak during the years 1965 and 1966.
  - ~ 5% of the total federal outlays.

Introduction cont.

- NASA's funding has varied over the past six decades.
- It has bottomed out this year.
- Out of 3.5 trillion dollars in the U.S. budget for the current fiscal year, only 0.5% (18.7 billion) is to be spent on the entire NASA space program.

Introduction cont.

- Considering the benefits, it is puzzling that the public opinion persists on the skeptical side.
- Ever since the Apollo program, two most frequently asked questions to this day are:
  - Why go into space when we have so many problems here on Earth to solve, and
  - What does the space program do for me?!

Technology Transfer Logistics

Technology Transfer Logistics cont.

- By a mandate of the U.S. Congress, NASA is obligated to promote dissemination of its innovation.
  - Other federal agencies, also involved with the research and development (R&D) with public funding, have the same obligation.
- The aim of this policy is to gain national benefit from publicly funded R&D in terms of secondary applications for new products, services, and jobs in the public sector.

Technology Transfer Logistics cont.

- Over the years, NASA has developed an immense reservoir of technological innovation for use in its aeronautics, earth science, and space missions.
- Some of this innovation has obvious potential for the public benefit.
- Commercial partners are actively solicited to use NASA's technology in their products.
  - Partners participate through licensing agreements, or as commercial entities and academia under a contract or grant with the federal government.

Technology Transfer Logistics cont.

- Each NASA center is responsible for licensing innovation of its own making.
  - License applications are processed by U. S. Patent and Trademark Office.
  - Subsequent to an award, each patent is entered into NASA's Technology Transfer Data System.
- All newly patented technology, excepting exclusive licensing, is added to the list of NASA technologies available for licensing to the general public.

Technology Transfer Logistics cont.

- NASA Technology Transfer Program enables a link between NASA and those in the public sector who might be interested, as well as able, to put new technology to beneficial use.

Technology Transfer Logistics cont.

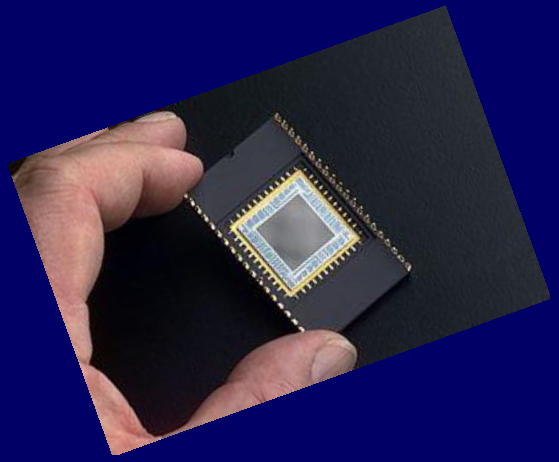
- NASA's Technology Transfer and Partnership Office (TTP) handles day to day logistics of partnering arrangements.
- The office is involved with technology development, technology transfer through licensing, commercialization and technology collaborations through partner infusion.

Technology Transfer Logistics cont.

- NASA is “spreading the word” of its “good deeds” for the American public.
- Spinoff success stories are written up in NASA’s own annual publication “Spinoff.”
- A searchable database of every NASA technology published in the last 40 years is maintained by the publication.

Technology Transfer Logistics cont.
Spinoff – NASA magazine

Space technology
In the service of life



In the service of life cont.

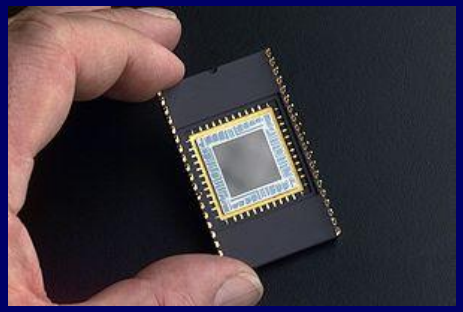
- Computer technology,
- Consumer, home and recreation,
- Environment and resource management,
- Health and medicine,
- Industrial productivity and manufacturing,
- Public safety, and
- Transportation.

In the service of life cont. Hubble example

Hubble telescope at work

Hubble example cont.

- Hubble Telescope summarizes the connection between the space innovation and public benefit.
- Charge Coupled Device (CCD) Detector is one of Hubble's many spinoffs.



Hubble example cont.

- Charge Coupled Device (CCD) Detector has found its use as a diagnostic device for digital imaging breast biopsies.
- These novel diagnostic tools are so advanced, that minute differences between a malignant and benign tumor can be detected without surgical biopsy.

Hubble example cont.

- Economic benefit of this NASA spinoff is immense.
- Over 500,000 women in U.S. alone are in need of breast biopsy annually.
- Cost of the CCD procedure is hundreds of dollars vs. thousands for a standard surgical biopsy.

Areas of technology penetration

Areas of technology penetration

- NASA innovation has penetrated the following areas of the public sector:
  - Computer technology,
  - Consumer, home and recreation,
  - Environment and resource management,
  - Health and medicine,
  - Industrial productivity and manufacturing, and
  - Public safety.

Computer Technology

Windows visual news reader

- Windows visual news reader (Win Vn) was developed by NASA to support payload technical documentation at Kennedy Space Center.
- Win Vn is now an enabling technology, that provides countless people with Internet access, which would have other wise remained beyond their grasp.

Ground processing scheduling system

- Ground processing scheduling system a computer-based system that uses artificial intelligence in managing thousands of overlapping activities involved in the Space Shuttle launch.
- Technology was licensed to a private company with explicit mandate to develop a commercial application.
- Commercial product in now widely used.
  - It enables such diversely complex tasks as real-time planning, optimization of manufacturing operations, integrated supply chains, and customer orders.

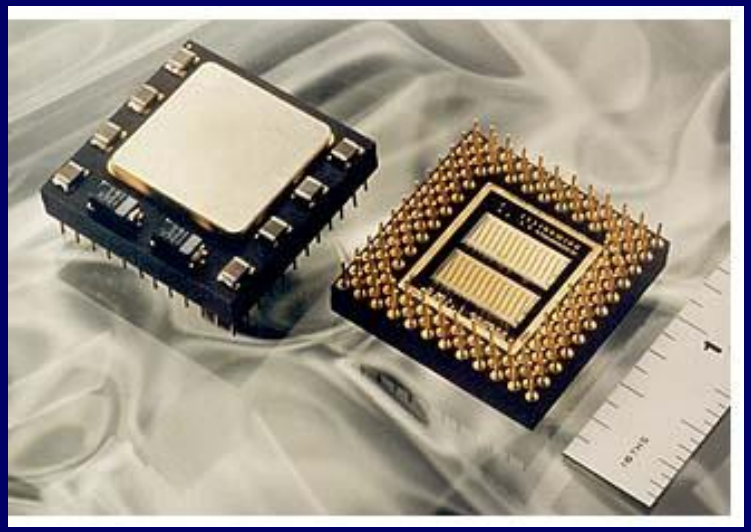
Structural analysis software

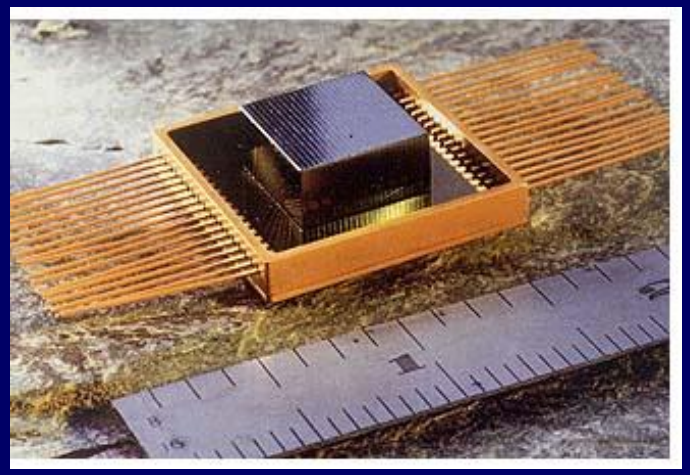
- Structural analysis software was originally created for NASA spacecraft design.
- The structural analysis technology is now successfully used in non-aerospace applications such automobile industry, manufacture of machine tools, and hardware design.

Air quality monitor

- Air quality monitor was created using a NASA-developed, advanced analytical technique software.
- The monitor is now successfully used in industry for oversight of compliance with the smokestack emission standards.
  - It is capable of separating various gases in bulk smokestack exhaust streams and determining the amount of individual gases present within the stream.

Memory short stack cont.





Memory short stack cont.

- Memory short stack is a result of NASA's requirement for dramatic reduction in size of space-borne hardware, along with faster computer processing speeds, high levels of integration and lower power requirements.
- Semiconductor curing enables dramatic reduction in size compared to conventional chip sets.
- Memory short stack spinoffs are now important in memory-intensive systems such as medical imaging devices.

Other spinoffs Computer Technology

- Other notable computer technology spinoffs include:
  - Advanced keyboard,
  - Laser surveying,
  - Aircraft controls,
  - Lightweight compact disc,
  - Microcomputers,
  - Design graphics, and
  - Customer service software.

Consumer/Home/Recreation

Enriched baby food

- Enriched baby food
  - “Formulaid” is a microalgae-based, vegetable-like oil developed from NASA sponsored research on long-duration space travel.
- Formulaid contains two essential fatty acids that are believed to be important to mental and visual development of infants.
  - These fatty acids are found in human milk but are absent in most baby formulas.

Water purification cont.

- NASA developed a water purification system that uses iodine rather than chlorine to kill bacteria.
- A municipal-size water treatment system has been designed explicitly for use in developing nations.

Scratch-resistant lenses

- Scratch-resistant lenses technology is derived from NASA's innovative dual-ion beam bonding process.
  - Lenses are coated with a film of diamond-like carbon.
  - Coating process also reduces surface tension on the lens, minimizing spotting by water droplets.
- The spinoff has made scratch-resistant lenses widely available and affordable.

Ribbed swimsuit

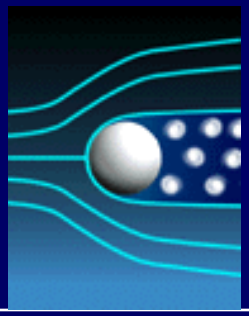
- Ribbed swimsuit is derived from NASA developed “riblets” material.
- Small, barely visible grooves in swimsuit material significantly reduce friction and aerodynamic drag.
- In test trials, the ribbed swimsuits outperformed any other world-class swimsuit by as much as 10 to 15 %.

Aerodynamic golf balls

Golf, golf, golf

Aerodynamic golf balls cont.

- Aerodynamical golf balls are derived from NASA's innovation in aerodynamics.
- A more symmetrical ball surface produces a "super" golf ball of superior performance.
- The ball's initial velocity is sustained longer than in more mundane counterparts, which, in turn, produces a more stable flight, better accuracy and distance.



Cardio-muscular conditioner system

- NASA's cardio-muscular conditioner system was tailored to maintain astronaut's fitness in weightlessness.
- This conditioner-exercising equipment is now widely used by athletes as well as amateurs for increasing muscular strength and to advance cardiovascular fitness.

Athletic shoes

- Athletic shoes are a spinoff from NASA's "Moon Boot" material.
- Encapsulated in mid-soles of running shoes, the Moon Boot material improves shock absorption and provides superior stability and motion control.

Other spinoffs in Consumer/Home/Recreation

- Other spinoffs in the area of consumer, home and recreation include:
  - Quartz crystal-timing equipment,
  - Flat-panel television,
  - High-density batteries,
  - Shock-absorbing helmets,
  - Home security systems,
  - Smoke detectors,

Other spinoffs Consumer/Home/Recreation cont.

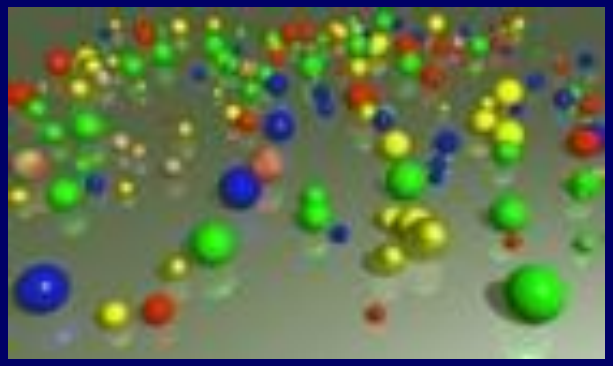
- Food-packaging and freeze-dried technology,
- Trash compactors,
- Fogless ski goggles,
- Self-adjusting sunglasses, and
- Hang gliders.

Environmental and Resource Management

Micro-spheres

- Tiny micro-spheres were the first commercial products made in orbit.
- The precise and relatively uniform dimensions of these tiny spheres permit their use as reference standards for extremely accurate calibration of instruments in research and industrial laboratories.
- Micro-spheres are now widely used in environmental control, medical research and manufacturing.

Micro-spheres cont.



Environmental and Resource Management cont. Hydroponics

Hydroponics cont.

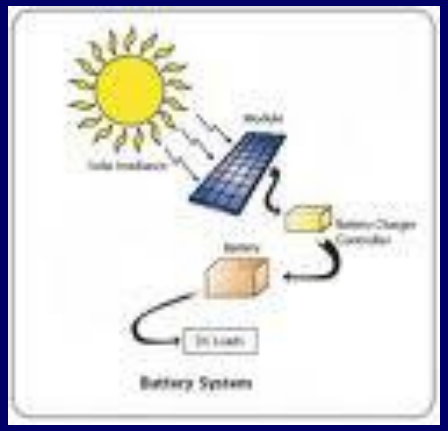
- Hydroponics technology is derived from NASA research in preparation for future Moon and Mars bases.
- Plant growth is supported by liquid nutrient solutions rather than soil.
- Hydroponics method is already a wide-spread industrial approach for profitable vegetable production here on earth.

Solar energy

- Solar energy is based on NASA photovoltaic innovation for supplying the spacecraft power needs.
- Photovoltaic power is now a viable alternative energy source, that is particularly important where no conventional power sources exist.
- An inspiring example of this is Pipistrel company in Slovenia, where photocell installations are providing for ongoing energy needs at a profit.

Solar energy cont.

Solar plant in the desert



Solar power charging the battery

Solar energy cont.

Solar panels for home

Global forest management

- Global forest management is NASA's initiative. A satellite has been put in orbits to monitor and map the forestation around the globe.
- Radiation, reflected and emitted from trees, is tracked and measured.

Fire protection

- Fire resistant material was developed by NASA to protect astronauts.
- Spinoff, which is chemically-treated fabric is now widely used in fire fighting business.
- Uniforms for hazardous material handlers, firemen clothing, and auto-racer and refueler suits are made out of this material.

Thermal insulation

- Aluminized polymer film is a highly effective radiation barrier for manned and unmanned spacecraft.
- Variations of this material are now extensively used as energy conservation techniques for improving thermal insulation of homes and offices.

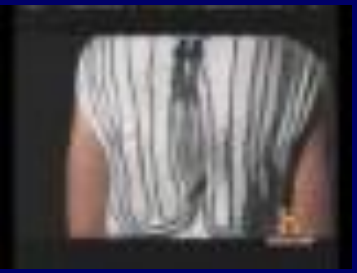
Other spinoffs Environmental and Resource Management, cont.

- Other notable spinoffs in the area environmental and resource management of include:
  - Environmental analysis,
  - Pollution measuring and control devices,
  - Radioactive leak detectors,
  - Air purification processes,
  - Earthquake prediction systems
  - Sewage treatments, and
  - Whale identification.

Health and Medicine
Laser angioplasty

- Laser angioplasty
  - Derived form NASA's excimer ("cool" type laser) technology.
- Laser angioplasty offers a non-invasive alternative to balloon angioplasty, which is currently the standard procedure.
  - Excimer laser does not damage blood vessel walls thus minimizing complications.
  - Precise, non-surgical cleaning of clogged arteries with extraordinary precision is enabled.

Cool suit



- Cool suit
  - Derived from astronaut space suits circulates coolant through tubes in order to lower body temperature.
- “Body cooling” therapy produces dramatic improvement of symptoms in such ailments as multiple sclerosis, cerebral palsy, spinal bifida and other similar conditions.

Human tissue simulator

- Human tissue simulator represents an ingenuous adaptation of NASA's space technology.
- A human tissue simulator is implanted in the body to help patients control chronic pain and involuntary motion.
  - Nerve centers or particular areas of the brain are targeted with electrical stimulation.

Medical gas analyzer

- Medical gas analyzer is derived from NASA technology for monitoring environment in the space habitats.
- Technology was adapted in medicine for the control of breathing environment of patients undergoing surgery.
  - Gas analyzer monitors operating rooms for analysis of anesthetic gases and for measurement of oxygen, carbon dioxide and nitrogen concentrations.

Voice-controlled wheelchair

- Voice-controlled wheelchairs are a happy fruit of NASA tele-operator and robot technology.
- Chair and manipulator system help invalids perform daily tasks, such as picking up packages, operating doors and turning appliances on and off.
  - Voice-controlled wheelchair responds to 35 one-word voice commands.

Voice controlled wheel chair cont.

Other spinoffs
Health and Medicine

- Other notable spinoffs in the area of health and medicine include:
  - Programmable pacemaker,
  - Implantable heart aid,
  - Arteriosclerosis detection,
  - Automatic insulin pump,
  - MRI,
  - Bone analyzer,
  - Ultrasound scanners,
  - Portable x-ray devices,
  - Cataract surgery tools, and
  - Automated urinanalysis.

Industrial Productivity and Manufacturing

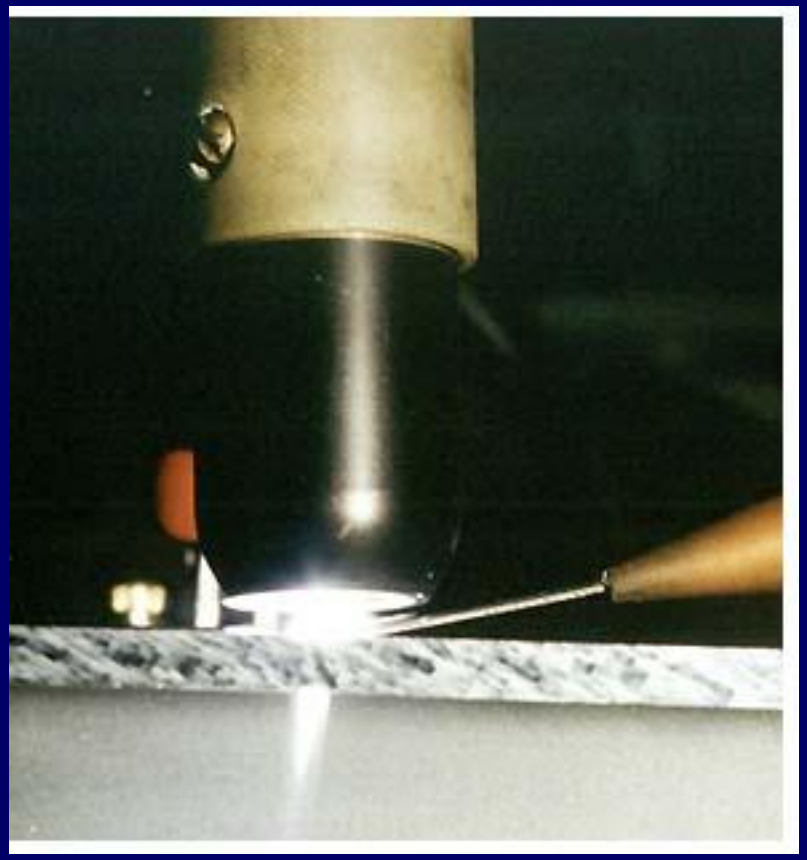
Welding sensor system

- Welding sensor system is derived from technology designed for Space Shuttle external tank.
- The sensor tracks weld seam where two pieces of metal are being joined together.
- Gaps and minute misfits are measured, and welding torch distance and height are automatically adjusted.

Advanced welding torch

- Advanced welding torch is derived from NASA Variable Polarity Plasma Arc welding technology, originally developed for joining light alloys in Space Shuttle external tank.
- A hand-held spinoff of the torch is now widely used by major appliance manufacturers for sheet metal welding.

Advanced welding torch cont.



Micro-lasers

- Micro-lasers are derived from NASA innovation for optical communication over interplanetary distances.
- Micro-lasers are now in wide use in diverse applications.
  - In addition to aiding in transmission of communication signals, micro-lasers are also imbedded in manufacturing processes for drilling, cutting, or melting materials.

Magnetic bearing system

- Magnetic bearing system is NASA innovation for movement of heavy machinery, such as Space Shuttle, without friction or wear.
- Magnetic bearings are now used in electric power generation, petroleum refining, machine tool operation and natural gas pipelines.

High-pressure water stripping

- High-pressure water stripping technology is NASA innovation for preparing Space Shuttle solid rocket boosters for launch.
- Only water, at an ultra-high pressure of up to 55,000 psi, is used in this application.
  - High-pressure water stripping is of double benefit. The process is cost effective as well as environment friendly.
- High-pressure water stripping reduces the costly paint removal time by a much as 90%.

High-pressure water stripping cont.

- The innovation evolved into U.S. Air Force's "Large Aircraft Robotic Paint Stripping" system.
- This spinoff is now widely used in commercial airline industry.

Other spinoffs Industrial Productivity and Manufacturing Technology

- Other notable spinoffs in the area of industrial productivity and manufacturing technology include:
  - Magnetic liquids,
  - Engine lubricant using plasma-sprayed coating,
  - Gasoline vapor recovery,
  - Self-locking fasteners,
  - Machine tool software,
  - Laser wire stripper, and
  - Wireless communication.

Public Safety

Stud-less winter tires

- Stud-less winter tires are based on innovative, chainlike molecular structure, devised for Viking Lander parachute shroud.
- The spinoff is manufacture of radial tires with greatly increased strength.
- The thread-life of stud-less tires exceeds their radial counterparts by over 10,000 miles.

Radiation hazard detection

Radiation detector

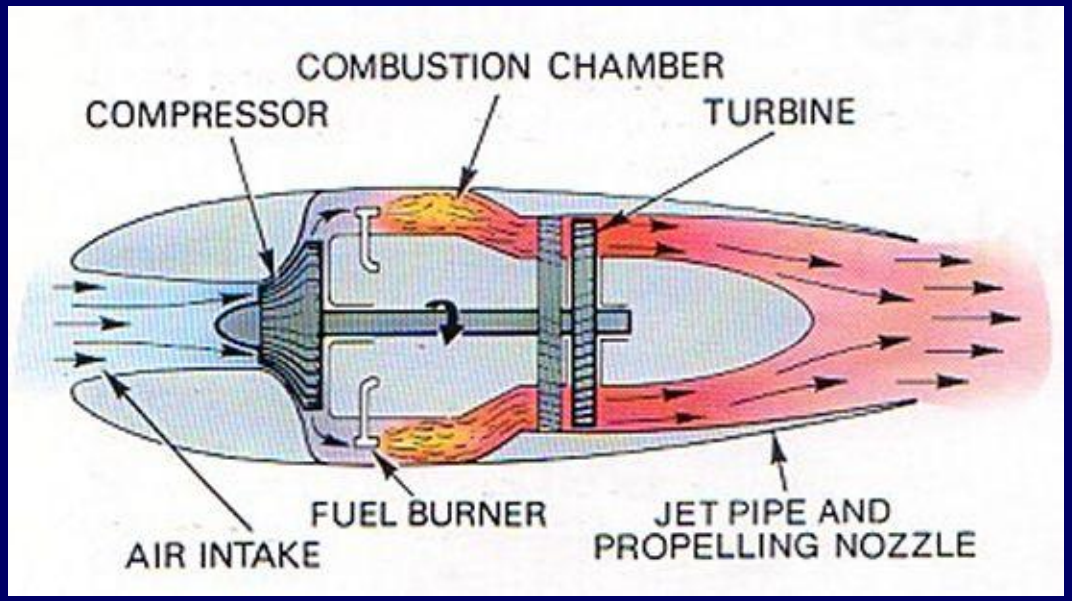
Radiation hazard detection cont.

- Radiation hazard detection is also a spinoff of NASA's innovation.
- The device for protecting people exposed to potentially dangerous levels of microwave radiation is now user-friendly and inexpensive.

Turbofan

Turbofan engine

Turbofan cont.



Concept

Turbofan cont.

- Improved aircraft engine or “high bypass turbofan” evolved from NASA’s multiple technological advancements.
- The turbofan is a move towards “green technology.
- This aircraft engine is cleaner, quieter, more economical than its conventional counterparts.
  - Improvements feature a 10% reduction in fuel consumption, lower noise levels, and emission reductions of oxides of nitrogen, carbon monoxide, and unburned hydrocarbons.

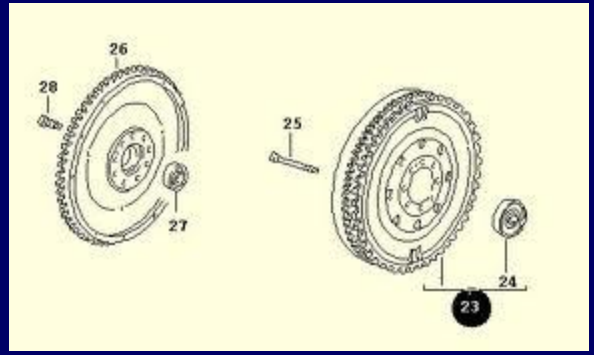
Advanced lubricants

- Advanced lubricants are derivatives of NASA's environmental-friendly lubricant, that was developed for Space Shuttle Mobile Launcher Platform.
- Spinoffs are "green" commercial lubricants for railroad track maintenance and corrosion prevention by electric-power companies.
- A hydraulic fluid with oxidation life of 10,000 hours has also been commercialized.

Flywheel

- Energy storage system – Flywheel is derived from NASA-sponsored energy storage studies.
- Flywheel is a chemical-free, mechanical battery that harnesses energy of a rapidly spinning wheel.
- Flywheel energy storage battery is a valuable technology for electric vehicles.
  - Battery has a storage capacity at 150 times that of its lead-acid counterpart.

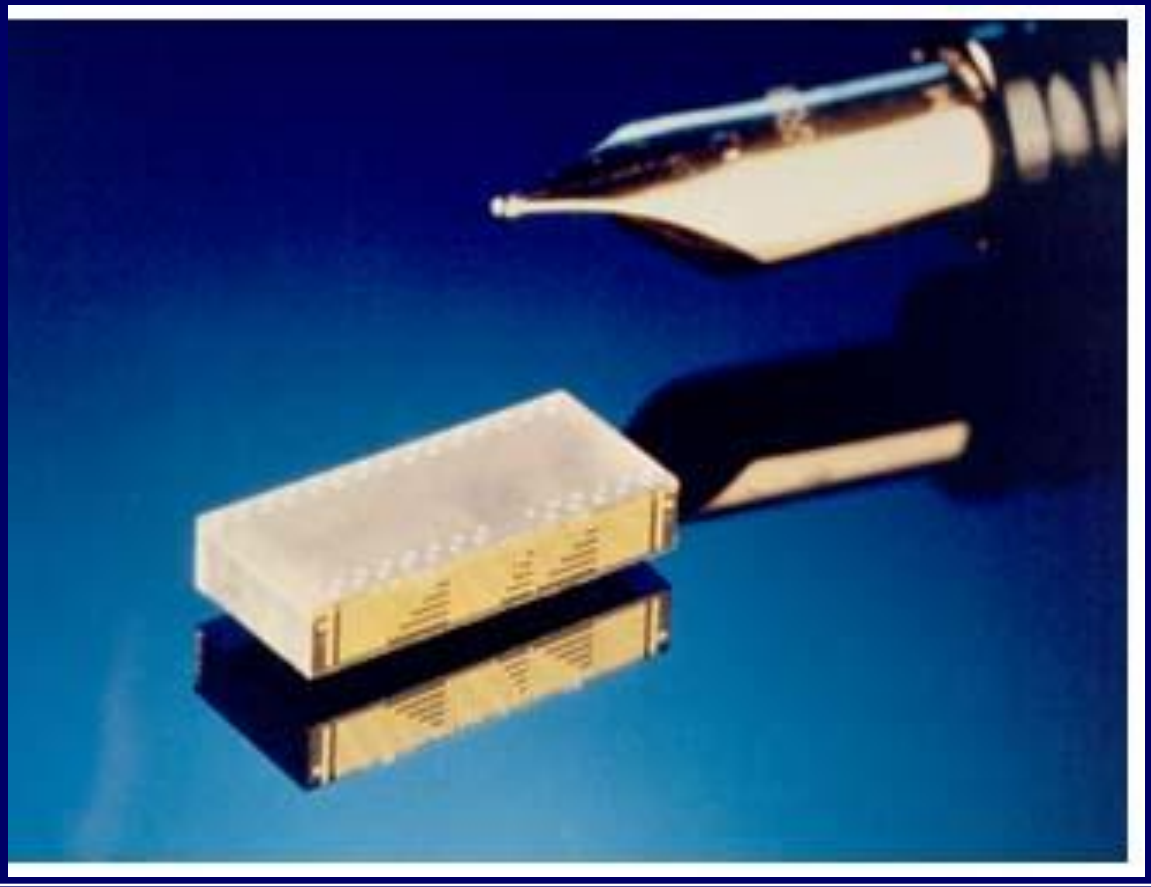
Flywheel cont.



Personal alarm system

- Personal alarm system is a spinoff from NASA’s space telemetry technology.
- Pen-sized transmitters are used by people in need - to call for help by prison guards, teachers, the elderly and disabled.
- Pen-device transmits silent signal to receiver displaying exact location of emergency.

Personal alarm system cont.



Other spinoffs
Public Safety

- Other notable spinoffs in the area of public safety include:
  - Safer bridges,
  - Emission testing,
  - Airline wheel chairs,
  - Electric car,
  - Auto design,
  - Methane-powered vehicles,
  - Wind-shear prediction,

Other spinoffs
Public Safety cont.

- Aircraft design analysis,
- Emergency robot response,
- Emergency rescue cutters,
- Firefighters radios,
- Fire and flame detectors,
- Lead poison detection,
- Corrosion protective coating,
- Protective clothing, and
- Robotic hands.

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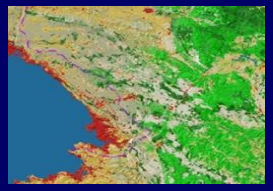
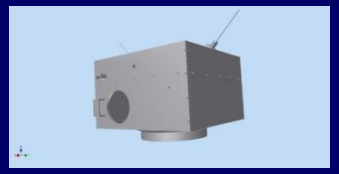
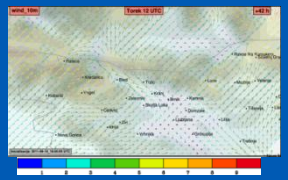
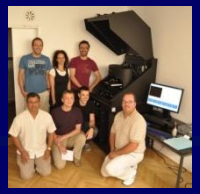
RTD PROGRAMME

SCIENCE	TECHNOLOGIES	APPLICATIONS
WP1: Remote sensing 	**WP4: Satellite Technolog.** 	**WP7: International missions** 
WP2: Meteorology 	**WP5: Communications** 	**WP8: Terrestrial applications** 
WP3: Astrophysics 	**WP6: Multidisciplinary lab** 	**WP9: Dissemination** 

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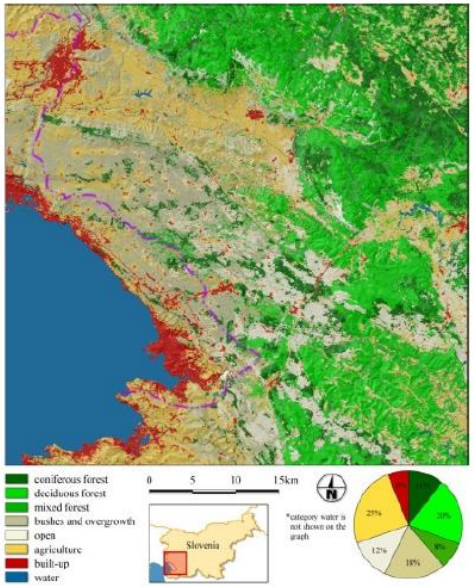
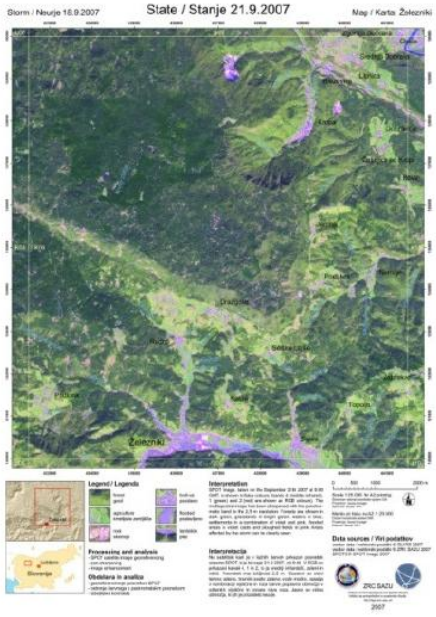
Remote sensing applications



(a) Land cover mapping

(b) Classification of agricultural crop



(c) Natural disaster monitoring

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Remote sensing applications

- Vegetation development cycle monitoring
- Drought and crops yield monitoring and mitigation
- Forestry managment monitoring
- Man made vegetation impact monitoring
- Environmental damage assessment
- Urban development monitoring
- Legal and illegal waste sites monitoring
- High precision relief and digital elevation modelling
- Topo and thematic charting and chart updating
- Water body monitoring and assessment
- Assesment natural disasters (floods, forest fires, mud slides)
- Archaeological site observations

Conclusion

- I trust my talk was informative in a positive way.
- I hope I have succeeded in helping you to better appreciate, that public funding of space initiatives and science in general is one of the better investments a nation can make.
- Perhaps, next time, when you hear a comment “What good is the space exploration anyway?,” you might be more inclined to be an advocate rather than a skeptic.