Space Transportation and Dual Use of Aerospace Technology

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I believe that a scientist looking at nonscientific problems is just as dumb as the next guy.

Richard P. Feynman

0. Content

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Mc Masters, 2006

1. The Need for Space Transportation

Do we need space transportation?

This is an invalid question, requirements are:

1. We need to know the **implications of space access**.
2. We need to know whether we can obtain **affordable space access**.

   Of much larger impact for the long-term development of societies are the **side effects of space technology**: education, access to top-technology, ability to handle very complex technical systems, advanced materials.

   These spin-off effects are very hard to estimate. One can proceed only based on the general experience that the leading technological societies perform space travel (the causal connection is not proven).

   Emerging industrial societies (Russia, China, India) believe in this causality (and we watch this with concern).

1. The Need for Space Transportation

Strategic Objectives of European Space Policy

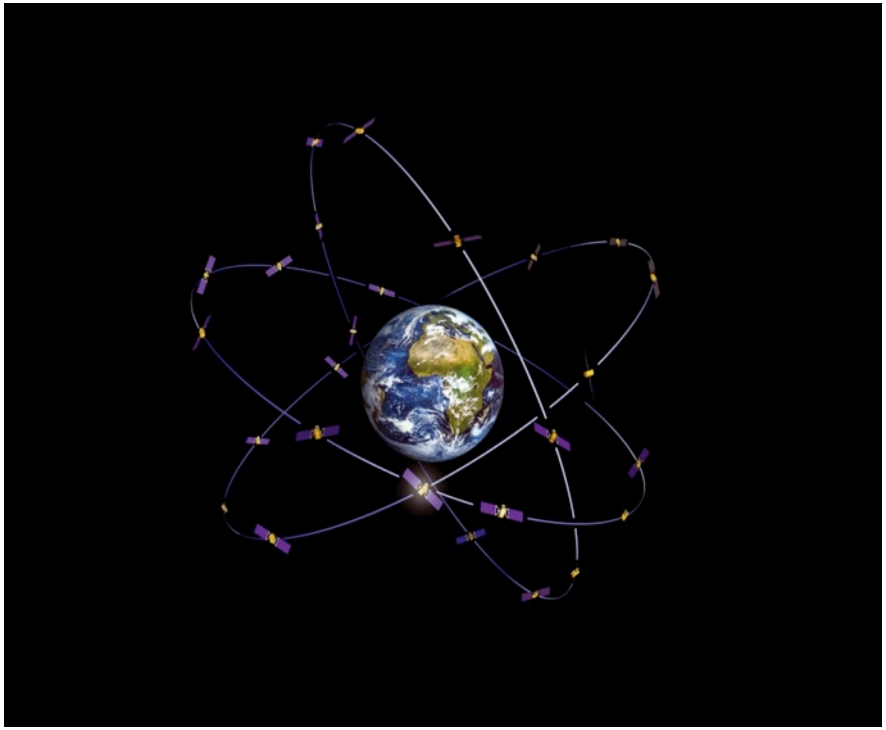
- Develop and exploit space applications serving Europe's public policy objectives and needs of European enterprises and citizens, including in the field of environment, development and global climate change.
- Meet Europe's security and defence needs as regards space.
- A strong and competitive space industry which fosters innovation, growth and the development and delivery of sustainable and cost-effective services.
- Contribute to knowledge-based society (science and exploration).
- Unrestricted access to new and critical technologies, systems and capabilities.

Independent access to space is an inevitable requirement for societies which rely on industrial revenue.

1. The Need for Space Transportation

Highlights of Space Exploitation

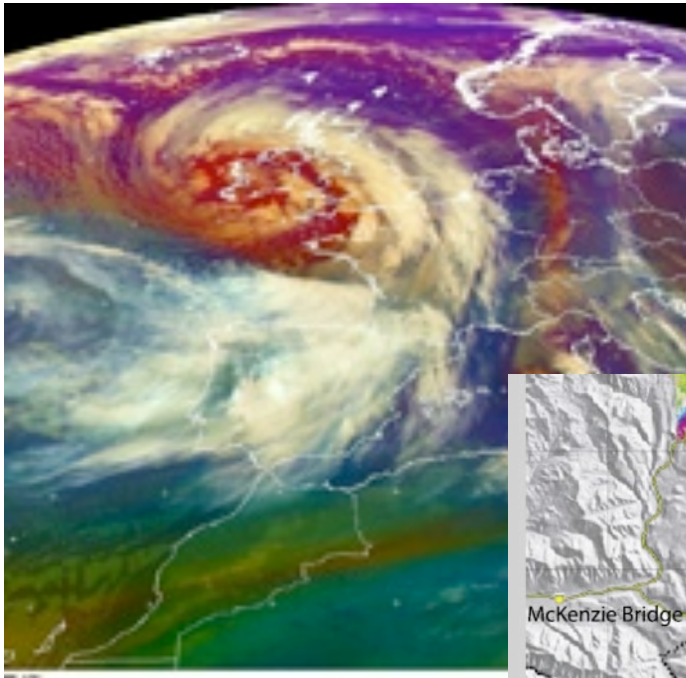
- Navigation, Positioning



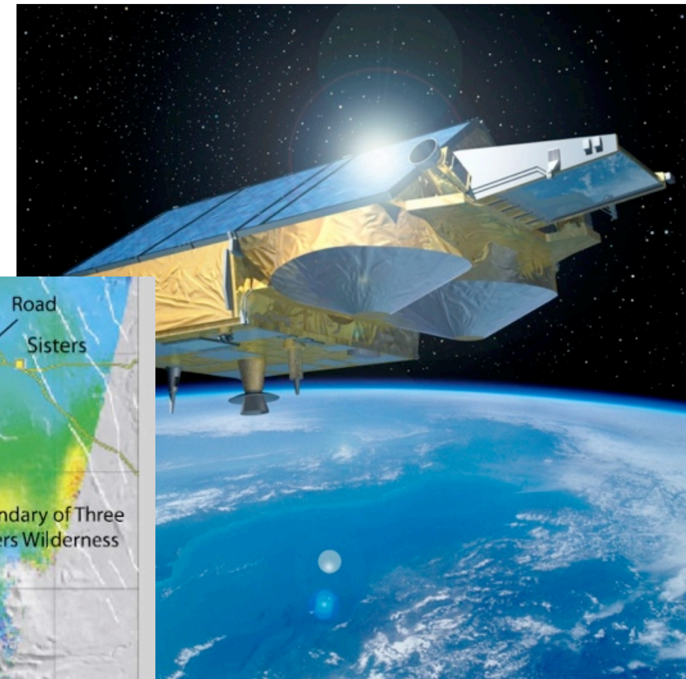
- Telecommunication

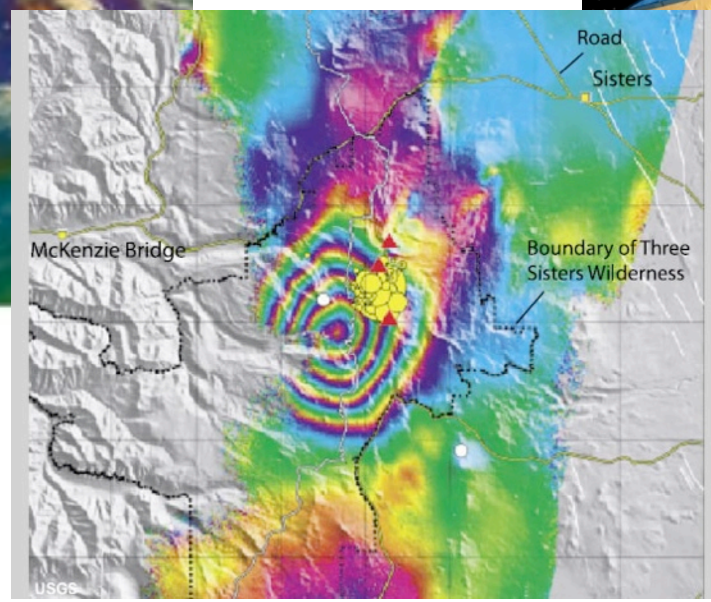
1. The Need for Space Transportation

- Weather Prediction



- Environmental Monitoring





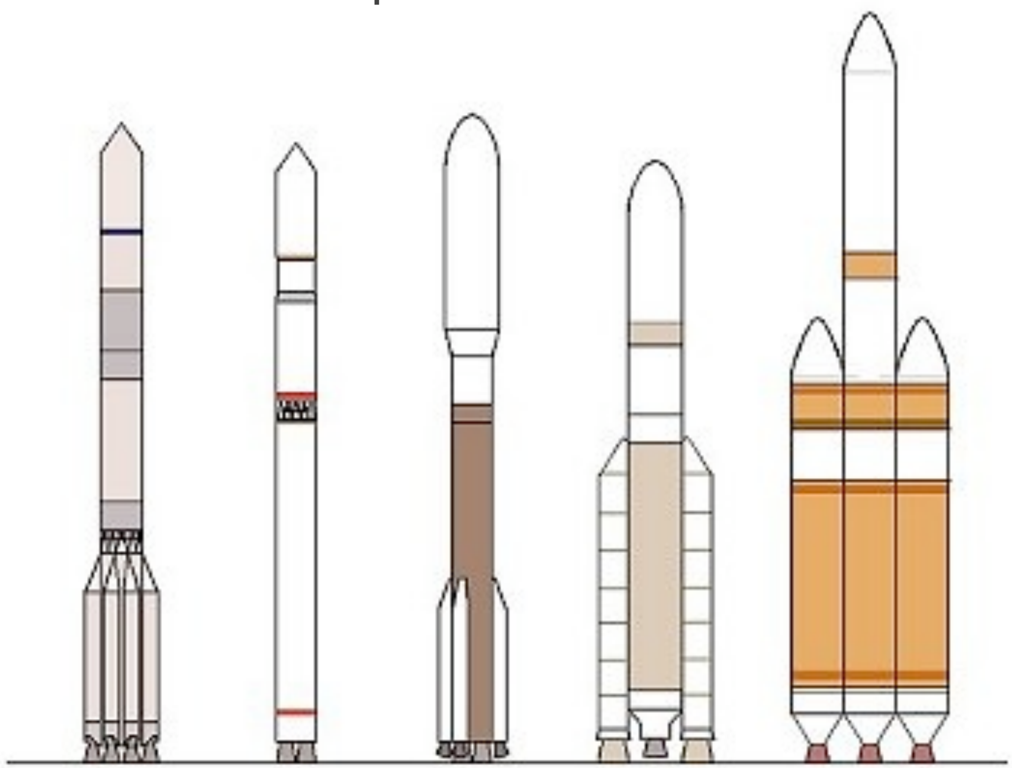
- Geological Surveillance

1. The Need for Space Transportation

- Unmanned-launch capabilites:
  - World revenue in satellite technology (2007) 123 Billion US$
  - Payload < 1,500 kg into low earth orbit or polar orbit (small observation satellites)
  - Payload < 3,000 kg into geostationary transfer orbit (communication satellites, weather satellites)
  - Payload < 10,000 kg into geostationary transfer orbit (weather satellites, large communication satellites)
  - Payload > 10,000 kg into low earth orbit (ATV service for ISS, Hubble space telescope)
- Manned-launch capabilities:
  - Payload < 25,000 kg into low-earth orbit (manned missions to ISS)
  - Payload < 20,0000 kg into low-earth orbit (manned missions to moon)

2. Current and Future Space Transportation Activities

- Current unmanned-launch capabilites:



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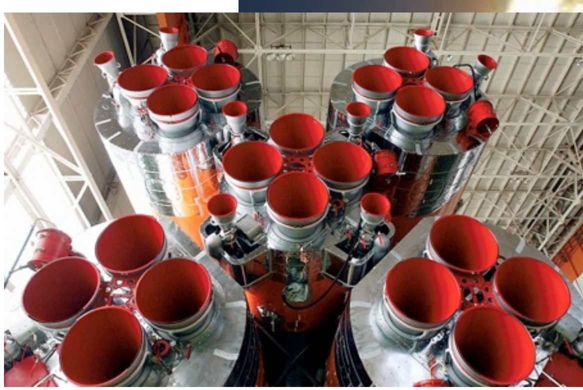
GLOW (TONNES)	680 T	467 T	500 T	777 T	725 T
NO. STAGES	4	3	6	4	4
GTO P/L (TONNES)	5.65 T	6.1 T	6.3 T	10 T	11 T

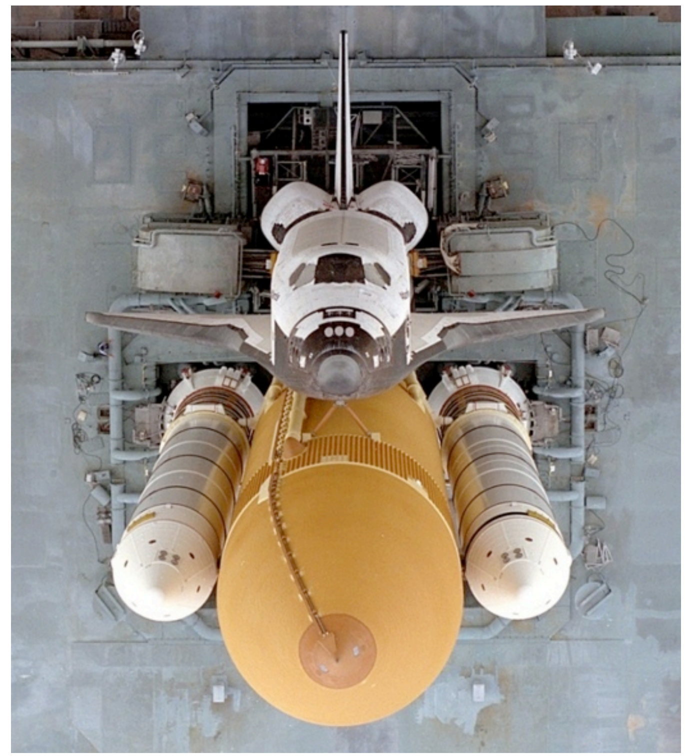
2. Current and Future Space Transportation Activities

Don't tell me that man doesn't belong out there. Man belongs wherever he wants to go – and he'll do plenty well when he gets there.

Wernher von Braun, 1958

- Current manned-launch capabilites:





2. Current and Future Space Transportation Activities

- Future manned-launch capabilites:

Europe:
Ariane 5 + ATV
evolution

US:
Ares I-V +
CEV

3. Individual Risk of Space Transportation (Example)

Opfer müssen gebracht werden.

Tombstone inscription of Otto Lilienthal.

– Film 1 –

Please click on the seperate button!

3. Individual Risk of Space Transportation (Example)

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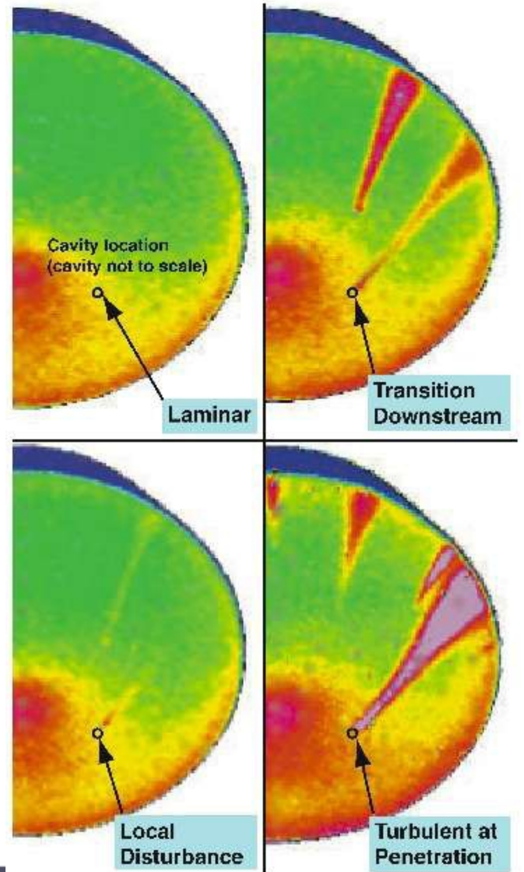
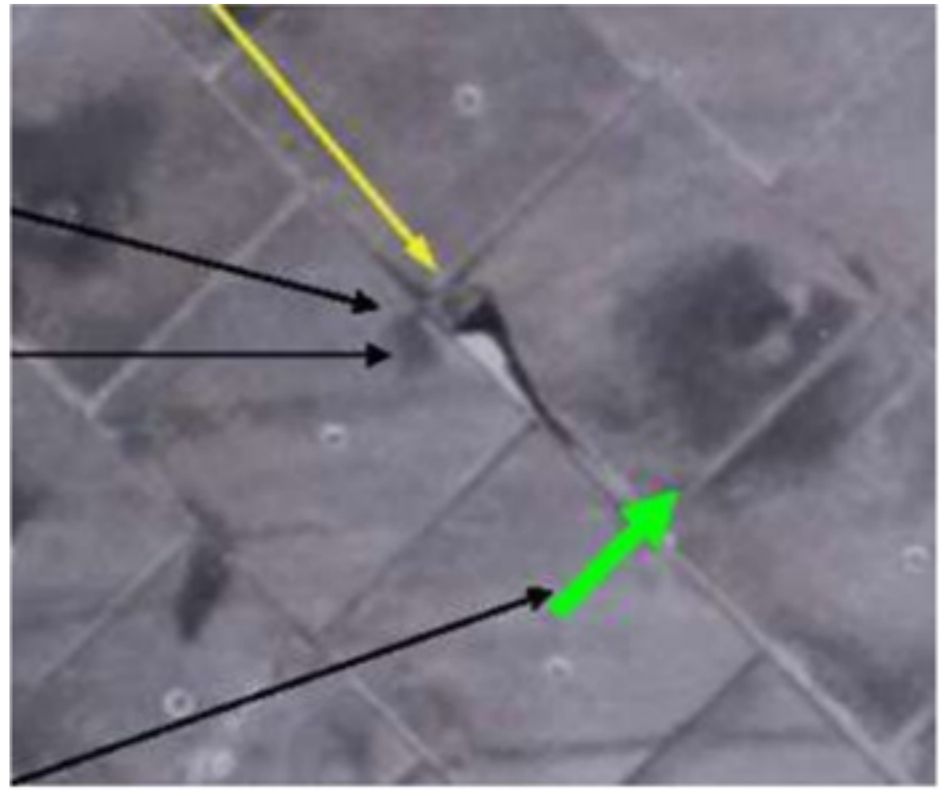
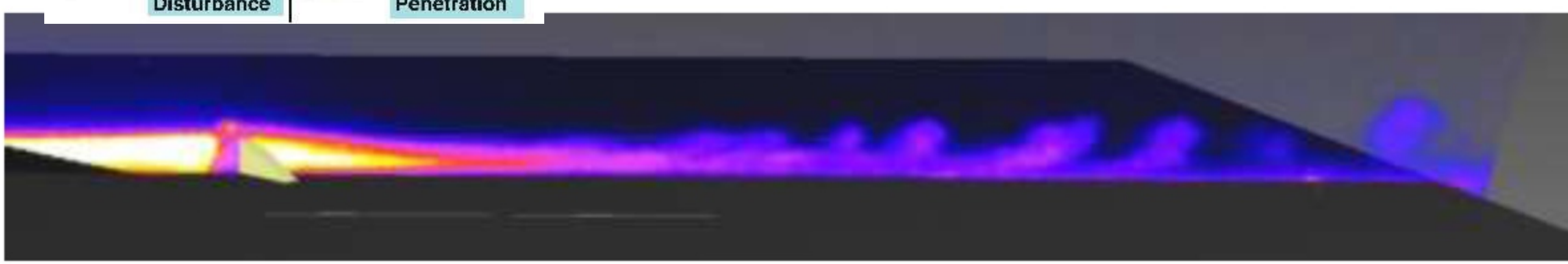






4. State of Space Technology and Current Research

On July 1, 2008, the German Research Foundation (Deutsche Forschungsgemeinschaft) decided to launch the Collaborative Research Center (Sonderforschungsbereich) TRR 40 at TU München, RWTH Aachen, TU Braunschweig and U Stuttgart with multi-million Euro funding for 4 years (with a possible extension to twelve years).

Astrium GmbH, industrial prime contractor in European Space Research, is an equal research partner providing significant additional funding.

The motivation is to maintain and extend research leadership in essential components of technologically extremely demanding components of future space transport systems.

– Film 2 –

Please click on the seperate button!

4. State of Space Technology and Current Research

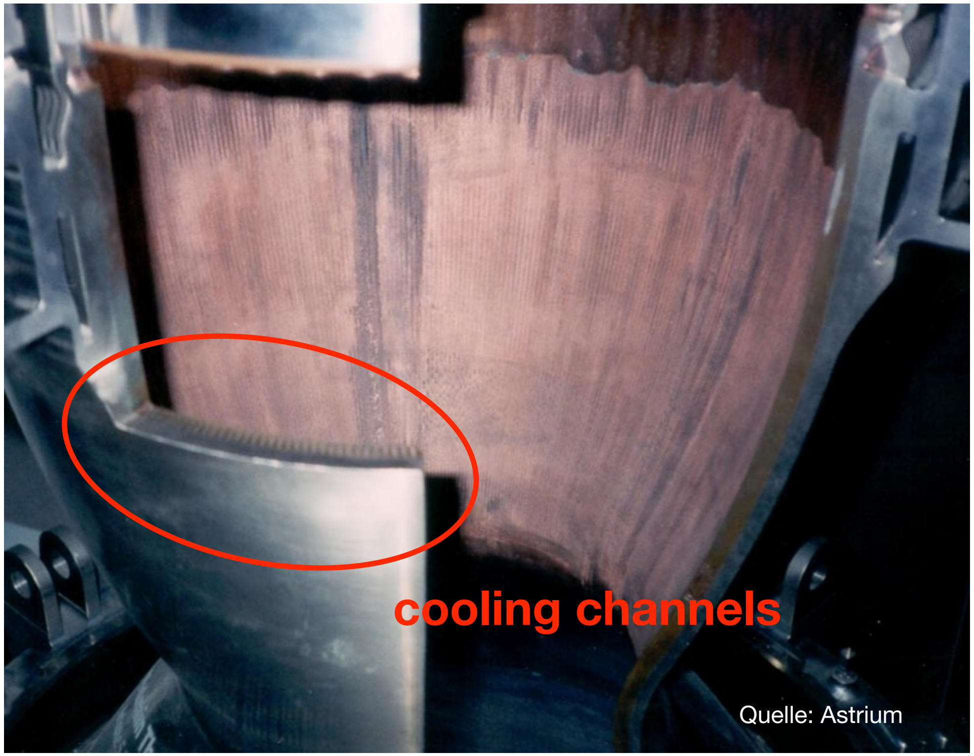
Data for Ariane 5 Vulcain 2 EPC main engine:

- Thrust 960-1350 kN
- Combustion chamber pressure 115 bar
- Fuel consumption 317 kg/s
- Combustion chamber has 566 injectors, 468 cooling channels
- Cooling power density 100 MW/m^2

- Interactions
  - nozzle flow ↔ exterior flow
  - shock ↔ boundary layer, shock ↔ shock
- Heat transfer, radiation
- Phase transition, combustion
- Boundary-layer and combustion instabilities

- Sonic conditions at about 7 km altitude
- Maximum aerodynamic load at about Ma=2
- Stagnation pressure about 0.5 bar
- Thermial load of the hull about 0.5 GW
- Unsteady turbulent, transonic wake, buffeting

Combustion chamber of the Vulcain engine:



- Failure of Ariane 5 EPC-main-engine nozzle on December 11, 2002
- Nozzle redesign and Ariane 5 re-launch on February 12, 2005
- Required investments: 400 M€

- ESA investigation:
  - Nozzle structure failure due to flight loads
  - Under-designed cooling
  - **Insufficient prediction due to ground tests**
  - **Insufficient numerical prediction**

- Measures:
  - Increase of cooling flow
  - Additional thermal protection
  - Additional reinforcements

4. State of Space Technology and Current Research

- Current technologies are largely empirical and experimentally developed
- Prediction models are calibrated on the final design or product

- New technologies and optimization of existing technologies are beyond the available development and prediction potential.

Needs:

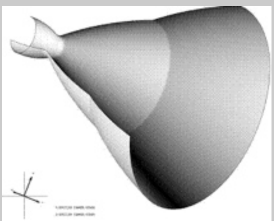
- Extend theoretical and fundamental knowledge.
- Understanding by modeling.
- Prediction by efficient and reliable simulation.

4. State of Space Technology and Current Research

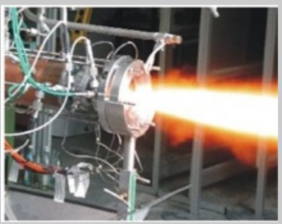
Break-through technologies for future space transport:

Robust Operation | Efficiency Improvement | Re-usable

1. New nozzle concepts




3. Innovative cooling concepts

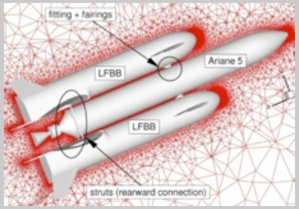



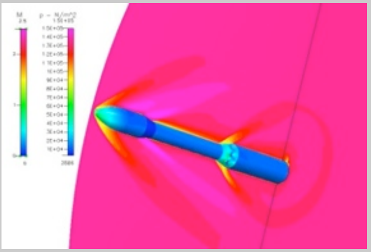
2. Alternative fuels and combustion concepts

LOX / Kerosin

LOX / Methan

4. Innovative methods for bluff-body wake flow control





5. Dual-Use Potential of Space Transportation

Although some people think scientists make war, I find it easy to take the position that war makes scientists.

Theodore von Karman in "The Wind and Beyond"

Any high technology has dual-use potential (actually, also almost any low-technology, too).

Any space transportation system which reaches earth orbit can serve to deliver weapons.

Any observation satellite can gather civilian or military information.

Any communication satellite can transmit civilian or military messages.

Any navigation satellite can deliver civilian or military positioning.

Any defensive system can be used for supporting offensive operations.

5. Dual-Use Potential of Space Transportation

Currently no space-based weapons (to public knowledge)—although USA declines an international treaty on that (probably with good reason).

Space technology used for reconnaissance and communication.

Ballistic rocket-based transport systems to deliver warheads are available even to low-technology societies.

Defence against such rockets requires highest-end technology, available currently only to USA (and possibly Israel), possible later solutions may require kinetic kill vehicles or lasers based in space (see above).

Kinetic anti-satellite weapons are available to USA, Russia and China.

Laser-based anti-satellite weapons (blindfolding) under development (known) by USA and China (alleged test against US satellite in 2006).

5. Dual-Use Potential of Space Transportation

Proliferation is the main risk for safety of free societies.

Can proliferation be contained?

Selling of technology is impossible to contain.

Can development by potentially threatening societies be prohibited?

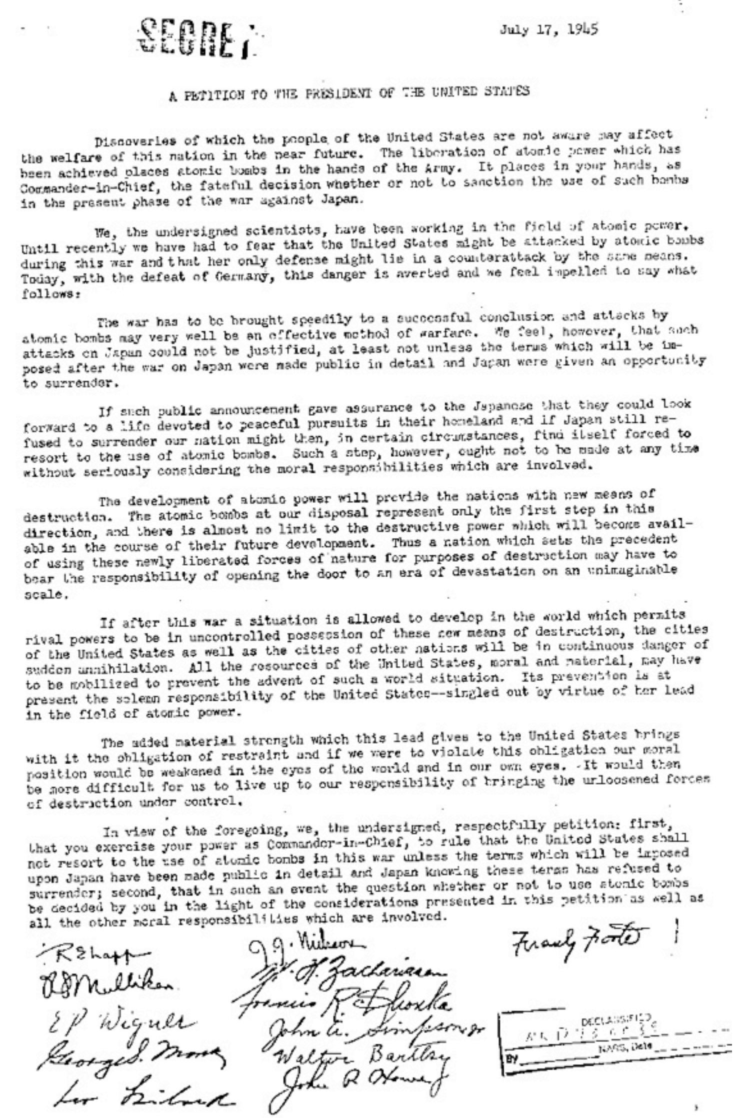
In the short term “yes,” in the long term “no.”

5. Dual-Use Potential of Space Transportation

Famous counterexample:

Argument of Szilard's July 17, 1945, petition (July 16 Trinitiy Shot) is essentially that by the USA's decision not to employ nuclear weapons the deployment of nuclear weapons could be prevented, respectively a nuclear-arms race could be avoided, for the foreseeable future as no one will know about their real power. Keep in mind that the development cost of a single weapon was 2 Billion US$ (reference 1945, 2 % of gross domestic product, would correspond to about 300 Billion US$ today).

Ignores that fact that also science (and not only technology or goods) can be proliferated (as we know now).



SECRET

July 17, 1945

A PETITION TO THE PRESIDENT OF THE UNITED STATES

Discoveries of which the people of the United States are not aware may affect the welfare of this nation in the near future. The liberation of atomic power which has been achieved places atomic bombs in the hands of the Army. It places in your hands, as Commander-in-Chief, the fateful decision whether or not to sanction the use of such bombs in the present phase of the war against Japan.

We, the undersigned scientists, have been working in the field of atomic power. Until recently we have had to fear that the United States might be attacked by atomic bombs during this war and that her only defense might lie in a counterattack by the same means. Today, with the defeat of Germany, this danger is averted and we feel impelled to say what follows:

The war has to be brought speedily to a successful conclusion and attacks by atomic bombs may very well be an effective method of warfare. We feel, however, that such attacks on Japan could not be justified, at least not unless the terms which will be imposed after the war on Japan were made public in detail and Japan were given an opportunity to surrender.

If such public announcement gave assurance to the Japanese that they could look forward to a life devoted to peaceful pursuits in their homeland and if Japan still refused to surrender our nation might then, in certain circumstances, find itself forced to resort to the use of atomic bombs. Such a step, however, ought not to be made at any time without seriously considering the moral responsibilities which are involved.

The development of atomic power will provide the nations with new means of destruction. The atomic bombs at our disposal represent only the first step in this direction, and there is almost no limit to the destructive power which will become available in the course of their future development. Thus a nation which sets the precedent of using these newly liberated forces of nature for purposes of destruction may have to bear the responsibility of opening the door to an era of devastation on an unimaginable scale.

If after this war a situation is allowed to develop in the world which permits rival powers to be in uncontrolled possession of these new means of destruction, the cities of the United States as well as the cities of other nations will be in continuous danger of sudden annihilation. All the resources of the United States, moral and material, may have to be mobilized to prevent the advent of such a world situation. Its prevention is at present the solemn responsibility of the United States--singled out by virtue of her lead in the field of atomic power.

The added material strength which this lead gives to the United States brings with it the obligation of restraint and if we were to violate this obligation our moral position would be weakened in the eyes of the world and in our own eyes. It would then be more difficult for us to live up to our responsibility of bringing the unloosened forces of destruction under control.

In view of the foregoing, we, the undersigned, respectfully petition: first, that you exercise your power as Commander-in-Chief, to rule that the United States shall not resort to the use of atomic bombs in this war unless the terms which will be imposed upon Japan have been made public in detail and Japan knowing these terms has refused to surrender; second, that in such an event the question whether or not to use atomic bombs be decided by you in the light of the considerations presented in this petition as well as all the other moral responsibilities which are involved.

R E Lapp
R S Mulliken
E P Wigner
George S. Monk
Leo Szilard
J. J. Nickson
W. H. Zachariasen
Francis R. Shonka
John A. Simpson Jr
Walter Bartky
John R Howe
Frank Foote

DECLASSIFIED
NARS, Date
BY

Leo Szilard Home Page - World-Wide Web - http://www.peak.org/˜danneng/szilard.html

5. Dual-Use Potential of Space Transportation

What can or should the individual scientist do?

Science!

As a note in passing:

More recent accounts of Heisenberg's role in the Nazi war machine indicate that it is likely that he in fact obstructed the decision-makers (Speer) from realizing the potential of nuclear research in terms of weaponry.

That gives rise to the ironic situation that Heisenberg was blamed by his former colleagues for cooperating with the Nazi government, whereas it rather appears that he prevented the necessary investments into nuclear bomb technology while his colleagues actively pursued its development.

Thomas Powers (Heisenberg's war, 1993) contradicts David Cassidy (Uncertainty, 1992) and Michael Frayn (Kopenhagen), and the conclusions of Jeremy Bernstein (Hitler's Uranium Club: The Secret Recordings at Farm Hall, 1992).