A European / Global strategy for Nanospacecraft Technology Testbeds for rapid, low-cost maturation of Space Microsystems

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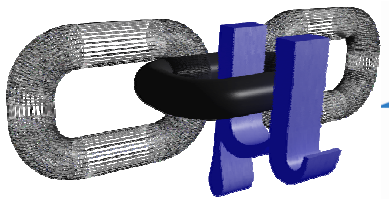
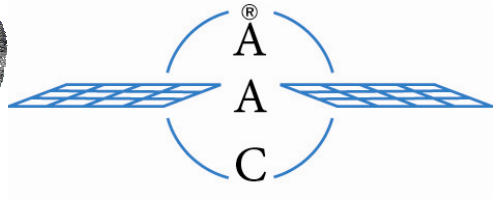




ESA 5th Round Table on Micro/Nano Technologies 2005

The Micro-Link Technology Program (MLTP)

- MLTP is proposed as a joint international program for rapid, low-cost space heritage for MNT systems currently within the ”valley of death”*
- A program to share the costs of bridging the TRL gap since no sponsor in neither the Low or the High TRL regimes have the inclination to do so.
- Based on the successful small-sat program of SSTL and the NanoSpace efforts of ÅSTC
- A collaboration with CANEUS
- A long term commitment with recurring spacecraft platform with different targeted masses (Nano, Pico, etc.)

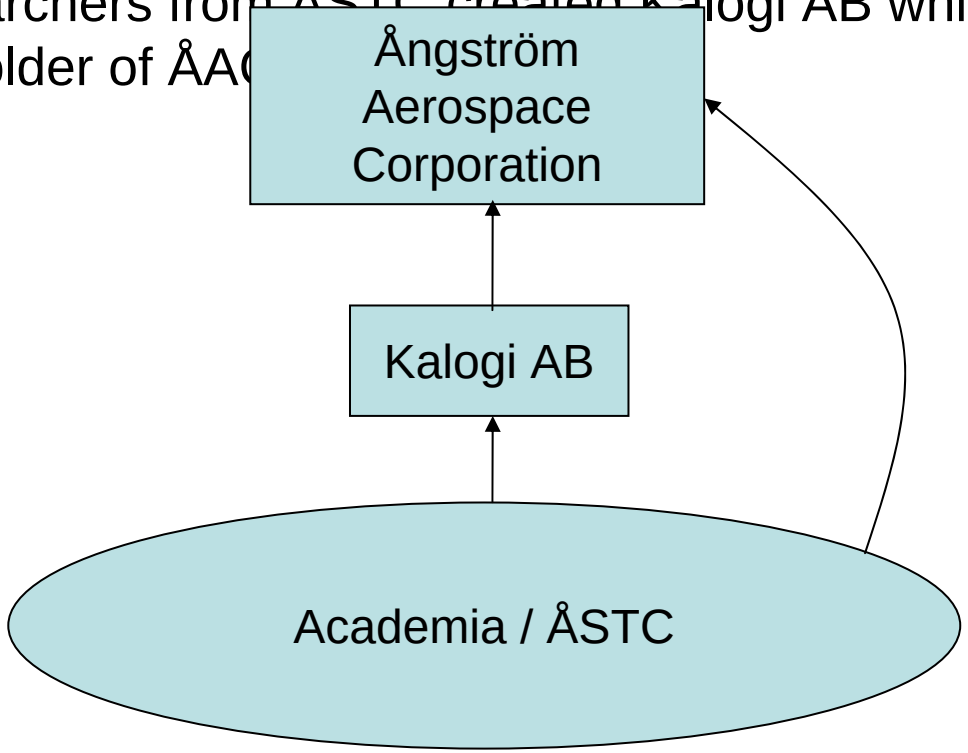
** The ”valley of death” is the region in development where devices or systems goes through rigorous testing and transforms into flight hardware*

Micro-Link Technology Program Drivers

- Reorganizing technology-development landscape; EC/ESA, JAXA, NASA et al.
- Recognizing the need for bridging mid-TRL (technology readiness level) barriers
- Spreading terrestrial applications (e.g., in autos, postal packages, earth monitoring) of micro and nano components
  - One complete MST/MEMS innovation system with a broad view has been set up around Uppsala University (Kalogi AB)
- Achieving more multifunctional integration of micro-nano elements into systems

ÅSTC and ÅAC

- Ångström Aerospace Corporation (ÅAC) is a uniquely spun-off company from the Ångström Space Technology Centre (ÅSTC)
- Prof. Lars Stenmark and Fredrik Bruhn are majority share holders
- All researchers from ÅSTC created Kalogi AB which is a share holder of ÅAC



Technology Readiness Level (TRL)

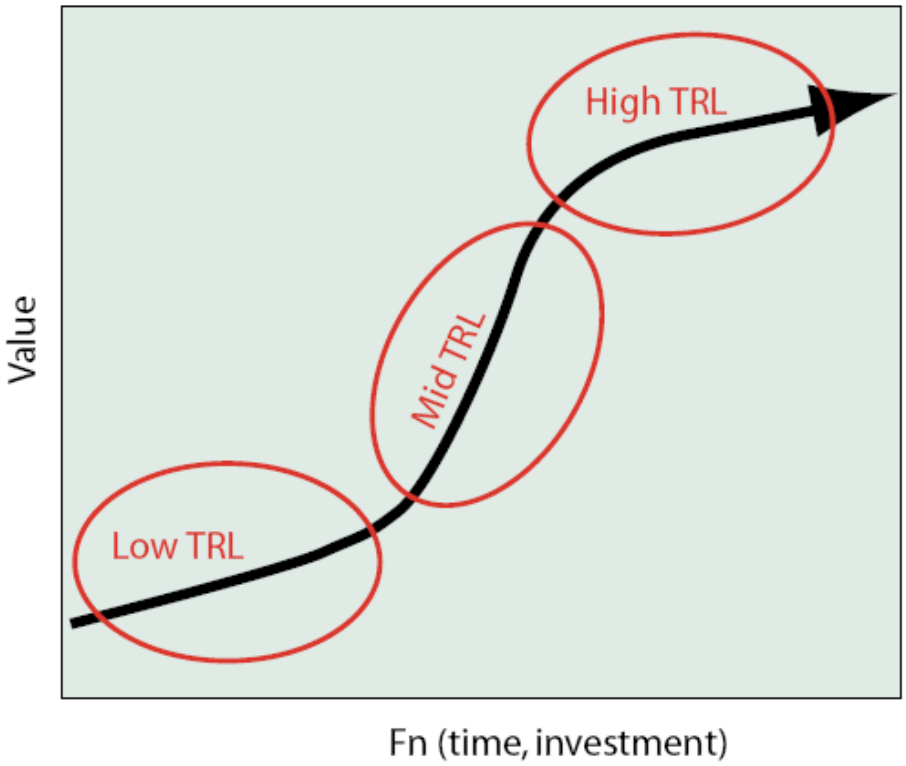
- Low TRL (1-3)
- Mid TRL (4-6)
- High TRL (7-9)

Technology Readiness Level (TRL) scale developed by NASA for assessing technology maturity

TRL1	Basic principles observed and reported
TRL2	Technology concept and/or application formulated
TRL3	Analytical and experimental critical function and/or characteristic proof-of-concept
TRL4	Component and/or breadboard validation in the laboratory environment
TRL5	Component and/or breadboard validation in the relevant environment
TRL6	System/subsystem model or prototype demonstration in the relevant environment (ground or space)
TRL7	System prototype demonstration in a space environment
TRL8	Actual system completed and flight-qualified through test and demonstration (ground or flight)
TRL9	Actual system “flight-proven” through successful mission operations

Cost

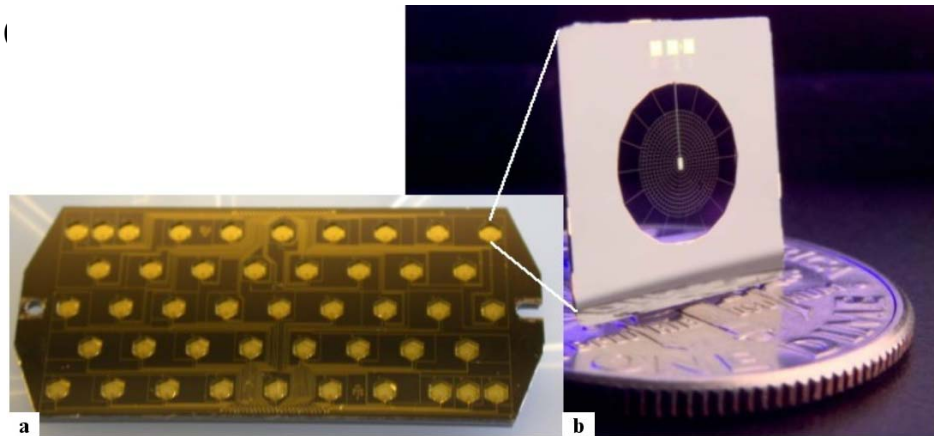
- Low TRL, typically 2-3 years in development (< $3M)
- Mid TRL, typically 2-3 years system level development (< $10M)
- High TRL, several years (> $10M)
- Europe can do this more efficient, perhaps up to 50% cheap



Cost (2)

- Small does not always translate into cheap!
- MEMS does not always translate into cheap systems!
- A 10 kg spacecraft with the performance of a 200 kg spacecraft will cost approximately the same. The cost is cut by getting more orders of the 10 kg version because of savings in launch costs and “mass” production.

- Example of MEMS systems that has successfully traversed the “valley of death”. The Spider web bolometer detector.
  - Why? Driven by PLAN(operates at 0.1-0.3K



Cost (3)

- Cheap recurring flight platforms are possible!
- Make sure that the test platform is representative for commercial spacecraft applications after qualification
- Make the platform modular and scalable
- The systems on each flight can be very expensive to develop

”Top down” vs ”bottom up” design

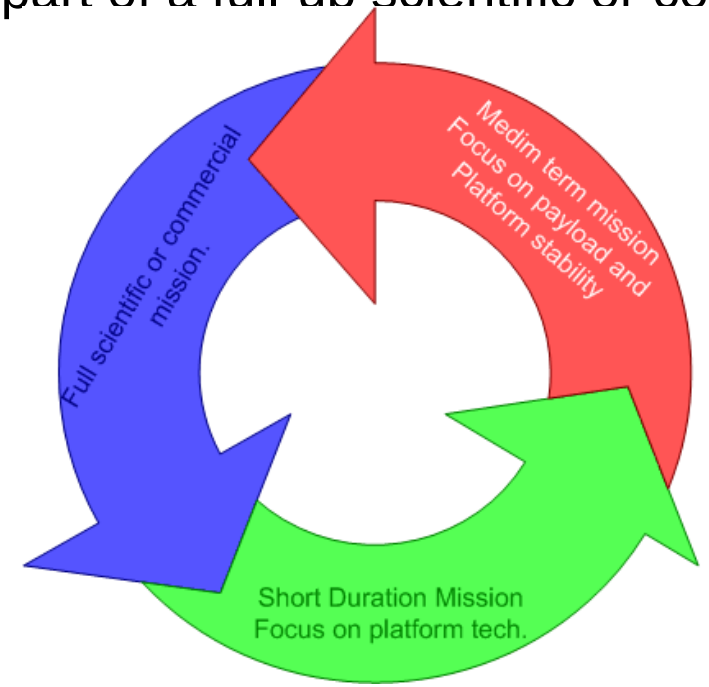
- The Top Down approach takes its origins from silicon integrated circuit technology, whereby lithographic techniques combined with deposition and etching processes have advanced to such a remarkable degree as to make 3-dimensional nanometer-scale structures possible.

- The Bottom Up or self-assembly approach, used primarily for nanostructures, an atom-by-atom synthesis takes place.

- The MLTP program shall accommodate both Top down and Bottom up approaches. However, top down approaches are expected to be in a vast majority.

Micro-Link three-phase approach

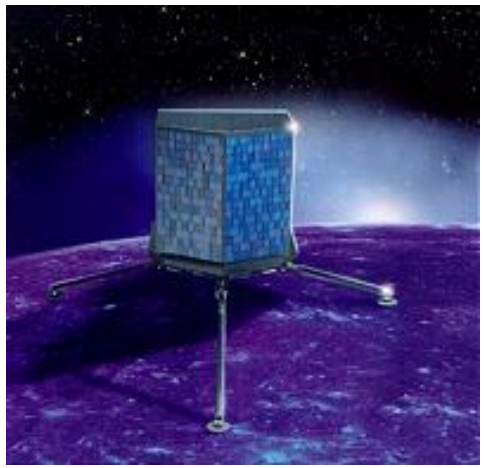
- The first phase of each new platform have a short duration mission and extremely high risk (Low TRL)
- The second phase is a mission to space-qualify the new technologies
- The third phase is the ultimate mission-insertion phase in which the newly space-qualified technology becomes an integral part of a full-up scientific or commercial mission



Micro-Link Discrete Payload Testing

- One major goal of the program is to attract and coordinate launch opportunities on participating members spacecraft for discrete payload testing in between regular MLTP flights

- Qualification for different space enivronments
  - Examples, spacecraft in Earth orbit, temperatures around 0-50ºC, a few kRad in radiation
  - Spacecraft on Europa, cryogenic temperatures, -145ºC, a few MRad in mission duration of hours.

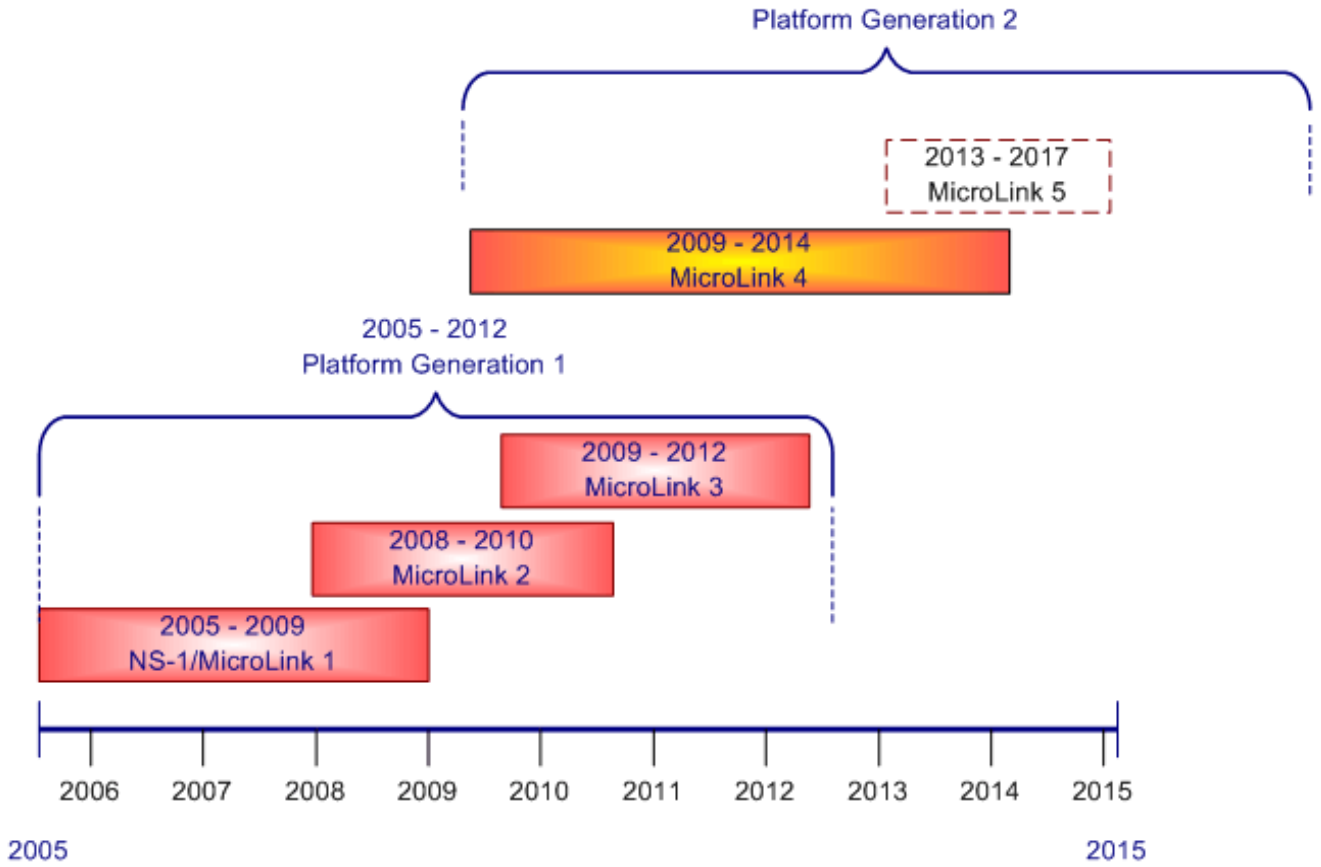


Micro-Link suggested development

- Generation 1, Micro/Nano spacecraft focus
  - Development and qualification of components, systems, and spacecraft for Micro/Nano and larger spacecraft
  - Relatively rapid incorporation in current planned scientific missions
- Generation 2, Nano/pico spacecraft focus
  - Development and qualification of components and systems for Nano/Pico spacecraft
  - Maturing of extremely small spacecraft and systems suitable for clusters and constellations requiring more planning and with a longer horizon
- International coordination of existing MEMS efforts and development of highly integrated MEMS systems by combining the best of several institutions

Micro-Link development and flight schedule

- Generation 1 has focus on Micro/Nano spacecraft
- Generation 2 has focus on Nano/Pico spacecraft



Micro-Link Organization Proposal

- An executive board (1 rep. from each partner / member / sponsor. ESA/NASA/CSA/... are counted as a member. One chairman is selected within the group.
- A legal board (IPR management, ITAR, EAR, ...). Should be chosen professionally and have one goal, ”Keep the program simple and open!!!”
- A proposal evaluation board (up to 7 people strong evaluation/screening proposal board. Selected by the Executive board)
- Program administration. Proposed to be handled by Ångström Aerospace Corp. and CANEUS.

Micro-Link funding

- Ideas welcome!
- Launch agreements with ISRO
- Launch agreements with Russians
- Nano/PicoSat Funding from CANEUS Canada ($15M) and System Integration Facilities
- Swedish National Funding through ÅAC

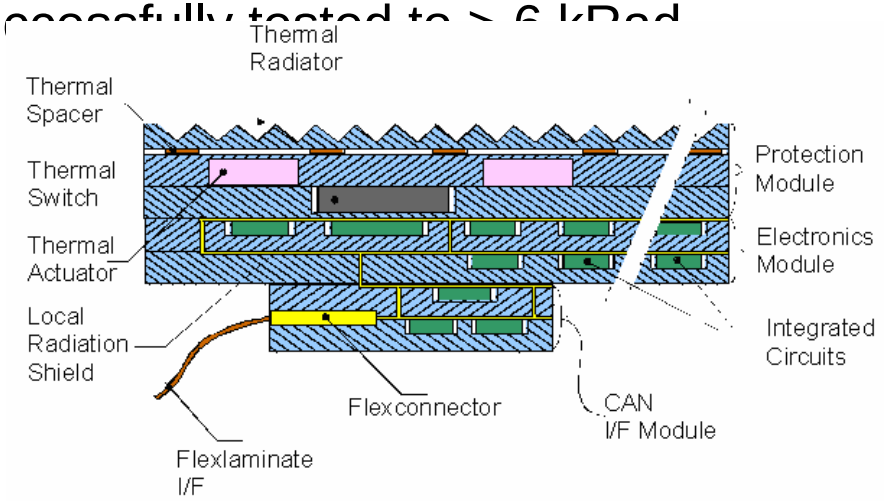
Micro-Link Contributions

- The Ångström Aerospace Corporation and Ångström Space Technology Centre offers the Micro-Link 1 (NanoSpace-1) platform as the first general platform
- Ångström Space Technology Centre offers new QA/PA MST routines/procedures developed with ESA for complex and highly integrated microsystems to the members of MLTP
- CANEUS offers international coordination and integration of the program
- Any interested companies, institutions, international or national organizations are welcome to bring hardware, software, components, new ideas, and direct funding to the table.

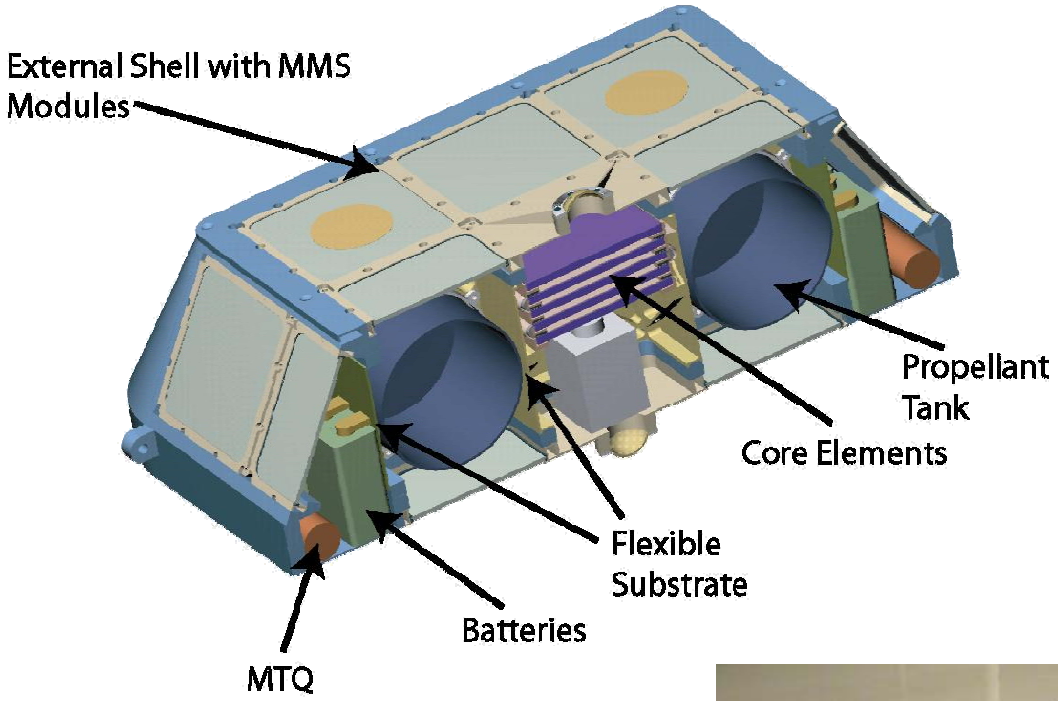
Micro-Link Contributions (2)

- The Ångström Aerospace Corporation is currently developing three miniaturized systems with funding from the Swedish Space Agency that benefit the Micro-Link TP. Flight qualification in 2007.
  - A miniaturized 3D-MCM mass memory (TRL 6)
  - A miniaturized Magnetic attitude control system (TRL 6)
  - A miniaturized CAN & SpaceWire user interface (TRL 6)

- COTS components for the miniaturized CAN & SpaceWire interface has been successfully tested to > 6 kRad

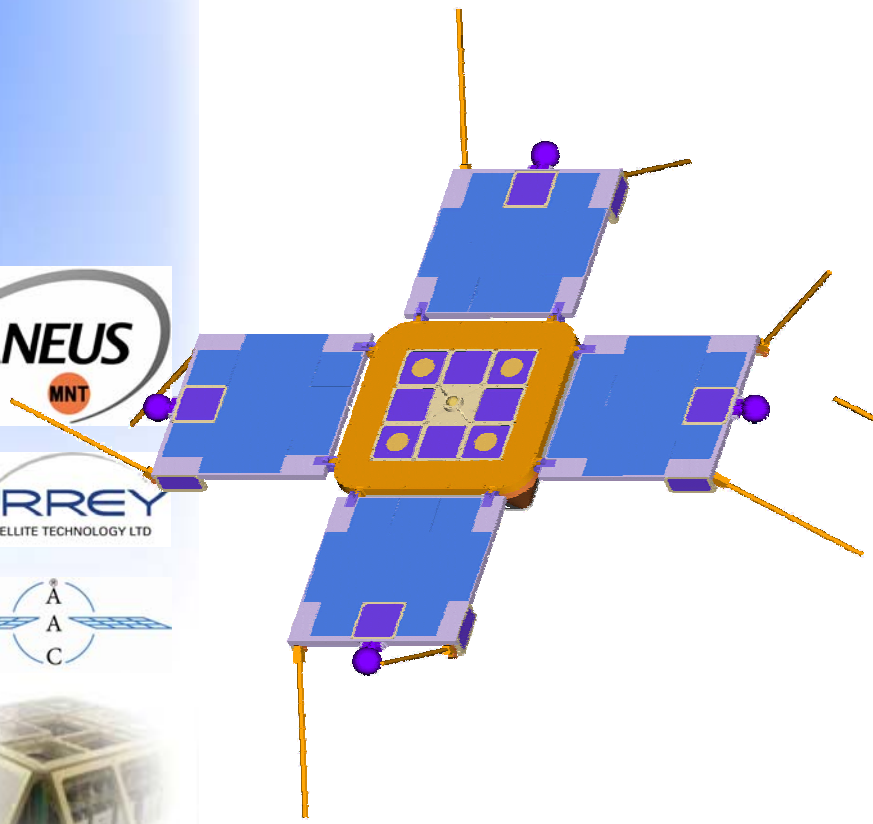


Proposed first platform (Micro-Link 1)

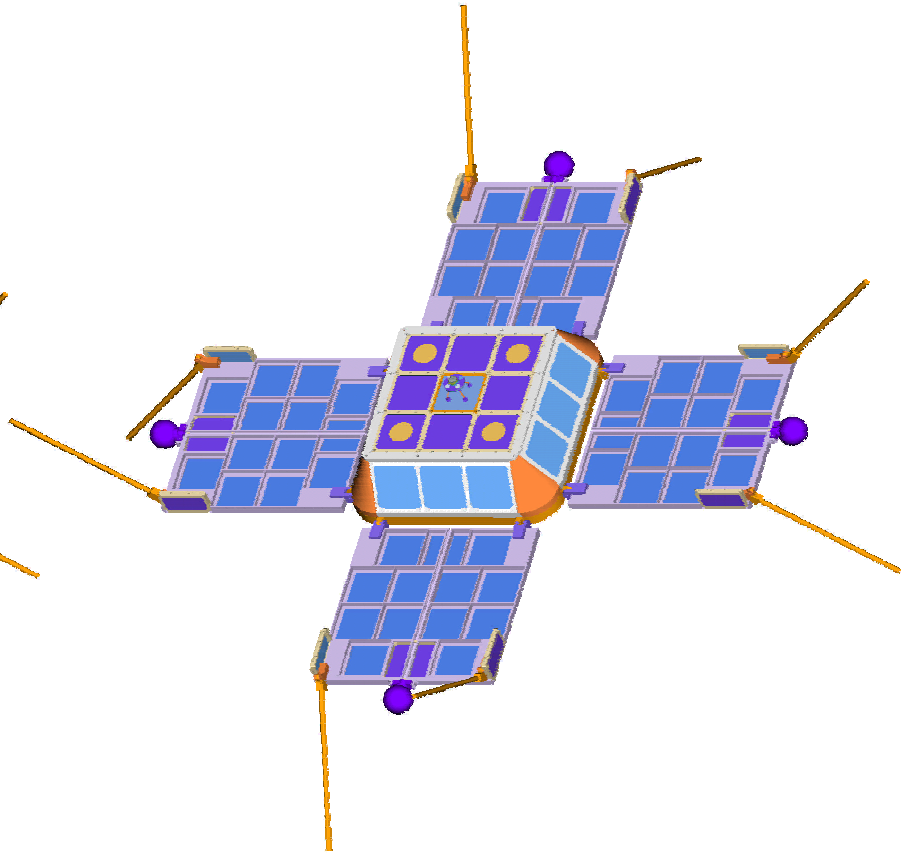


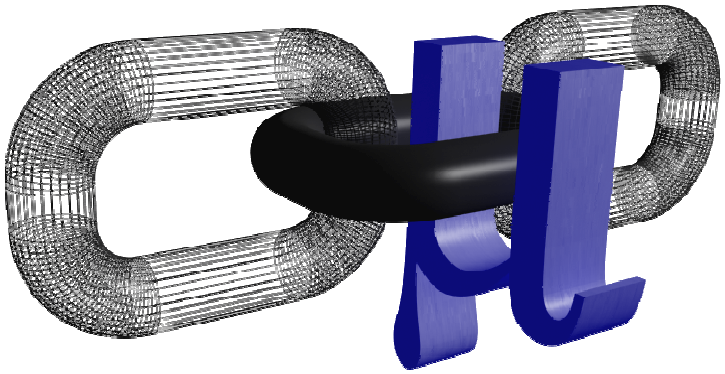
Micro-Link 1 Flight Configuration

- Front side



- Back side





www.micro-link.se

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