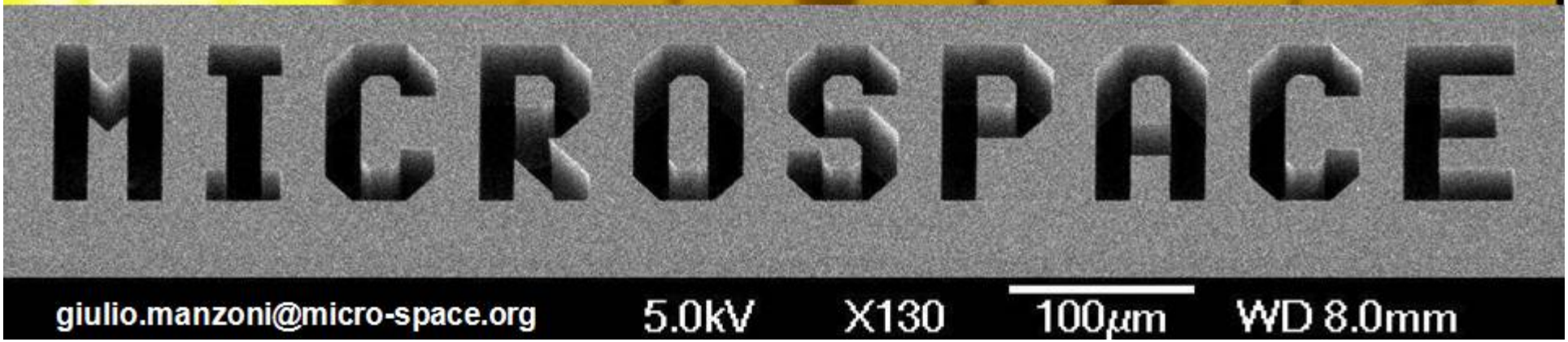
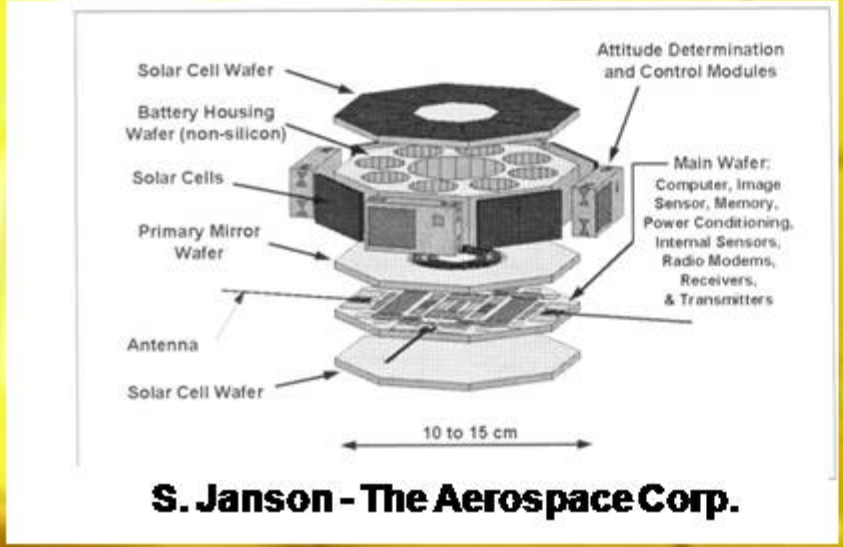
Microspace Micropropulsion Roadmapping, Strategy and R&D Achievements

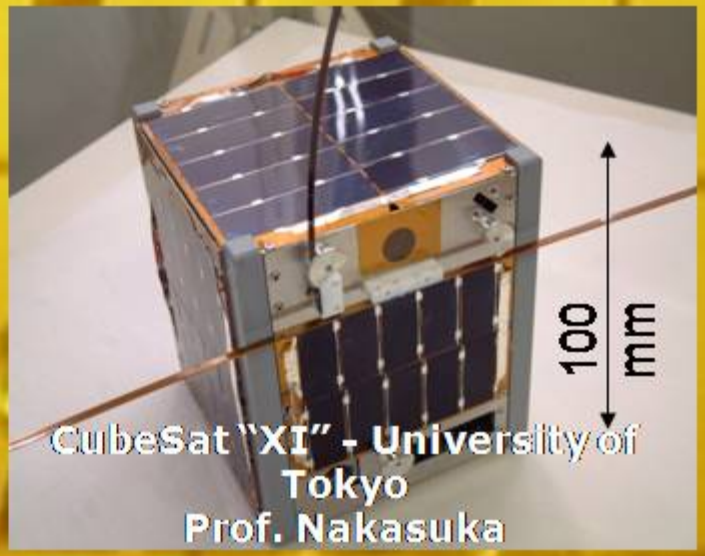
ESA MNT07 – 8/10/2007, G.Manzoni

- Introduction
- Strategic Roadmapping
- Tactical R&D program
- Micronozzle Critical Development
- Micropropulsion Systems
- Application on Cubesat & Nanosat





S. Janson - The Aerospace Corp.



Microspace Nanosatellite micropropulsion offer.

A hybrid technology, highly modular miniaturized , MEMS based system.

Programmatic Statements

Mission target:
To bring to reality the concept of micropropulsion for nanosatellites

Methods:
To operate together with important players and the best partners and optimally tuned mix of mission driven technologies

Constraints:
To limit external constraints by keeping an independent identity to fulfill the mission efficiently and effectively

Roadmapping, dimensions problem breakdown :

Programmatic Statements

- Strategic targets
- Application field
- Potential markets, actual clients
- Specifications and requirements

targets

- System, subsystem, devices, parts breakdown
- Physical behaviors
- Manufacturing technologies
- Competencies and human resources

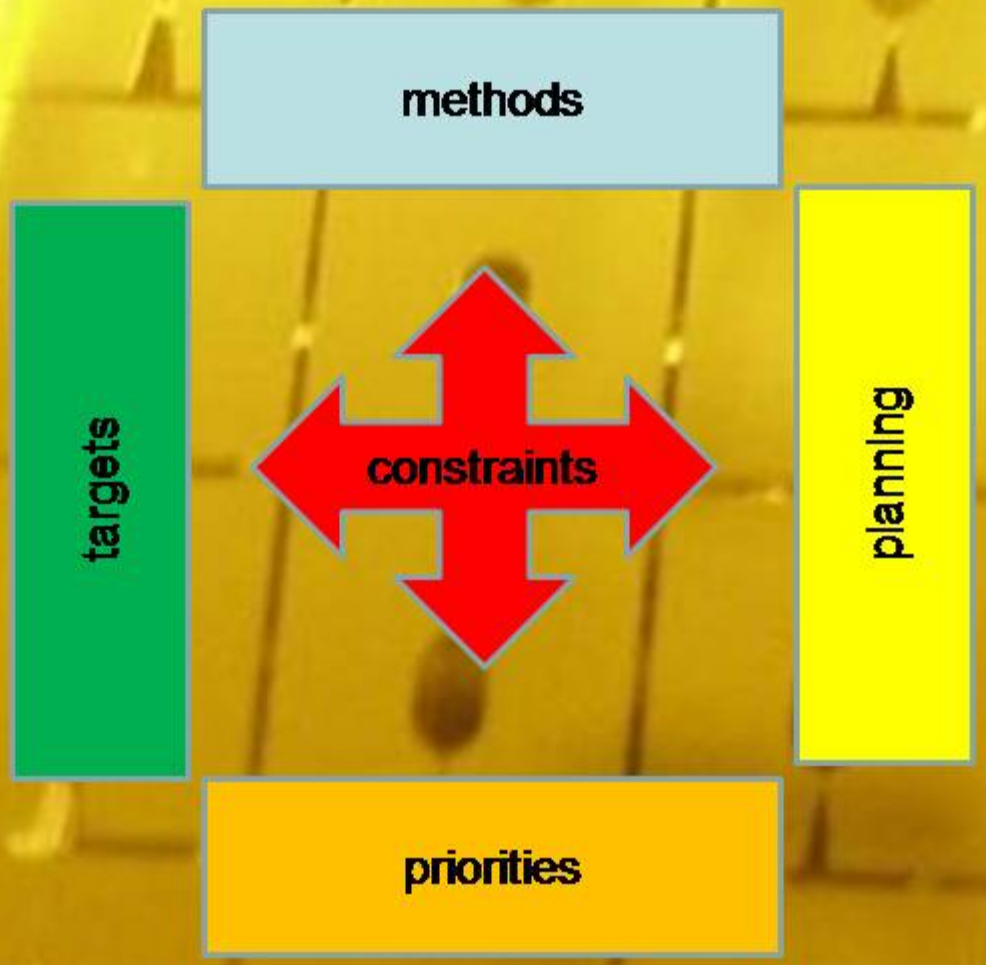
methods

- R&D Financing
- Governments policies and politics
- Client-prime-subcontractors interaction
- Geography, logistics, borders
- Promotion and know how protection
- Time

constraints

From strategy to planning

Targets and methods are analyzed under the constraints to produce priorities among the methods and planning in the achievement of the targets. Tools such as Quality-Function-Deployment (QFD) are used.



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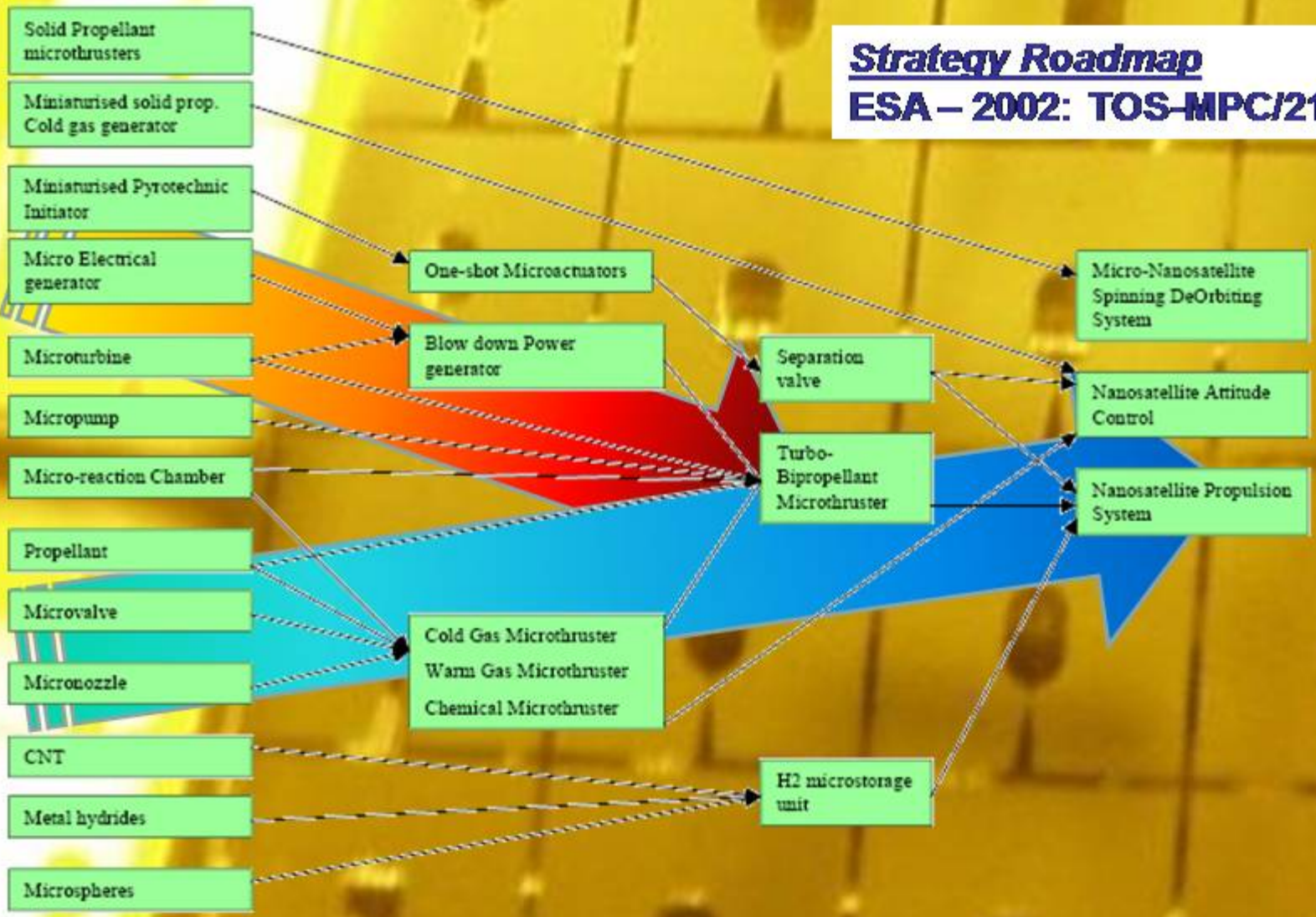
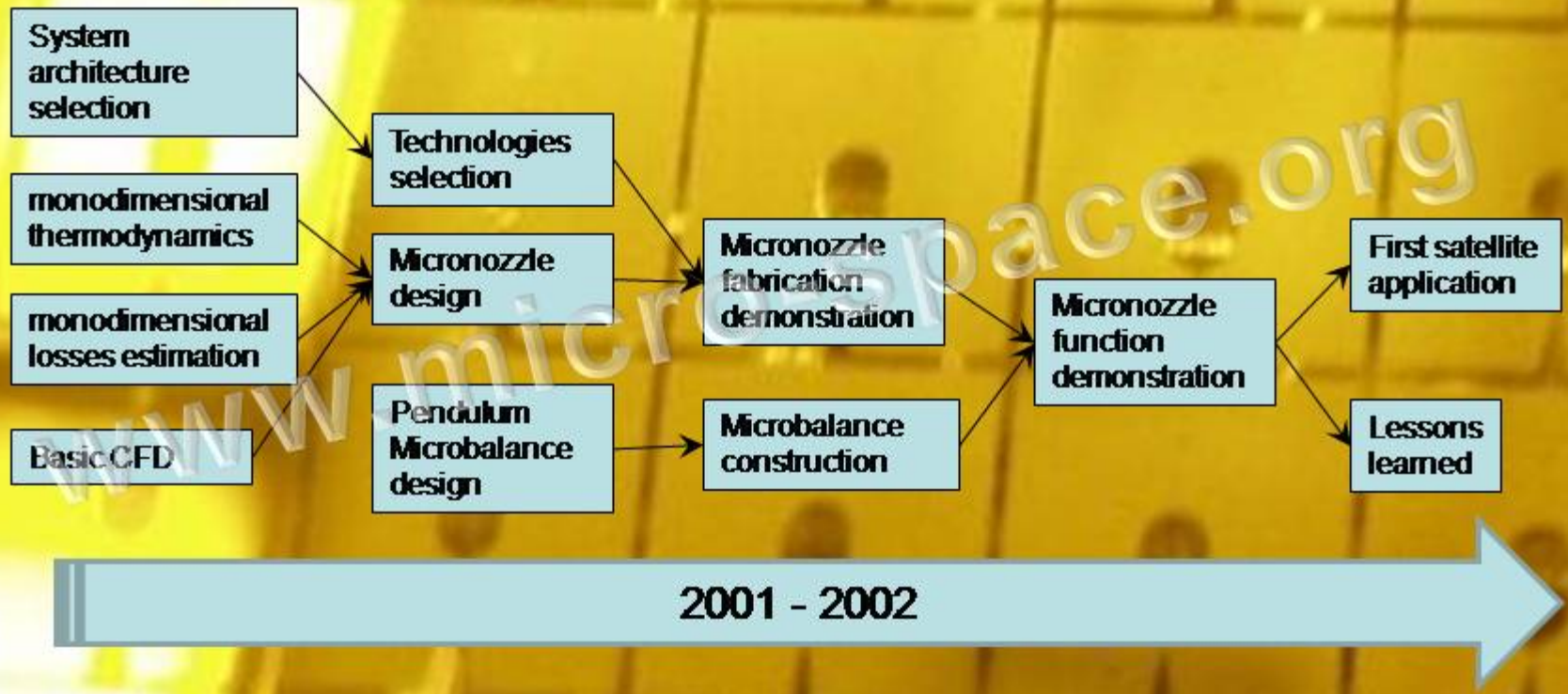
Strategy Roadmap

ESA – 2002: TOS-MPC/2168/ML

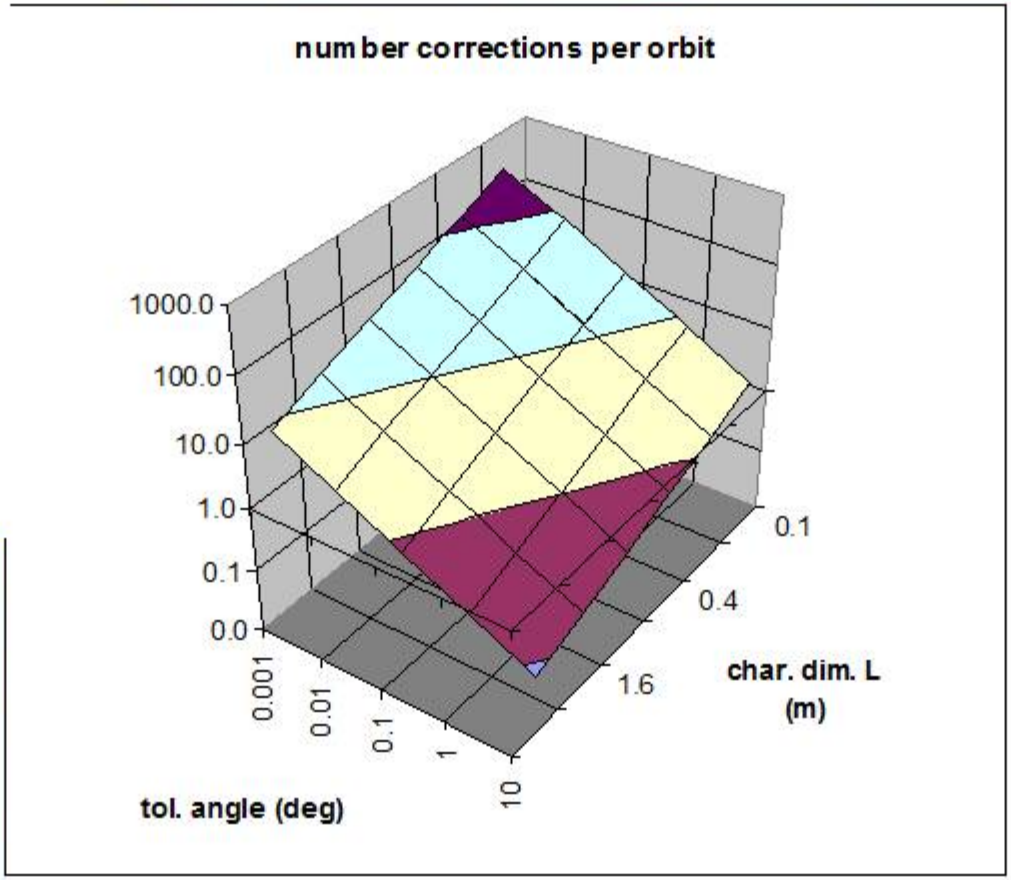


Tactical plan – 1st R&D iteration for Micronozzle building block: "exploration"



System Architecture and thruster technology selection:

Cold-Gas Micropropulsion



$$n = \frac{t_{mission}}{t_{man}} = \frac{t_{mission}}{4\sqrt{\frac{2\theta_{max}}{\dot{\omega}}}} = \frac{t_{mission}}{4\sqrt{\frac{2\theta_{max}}{T/I}}}$$

Specifications

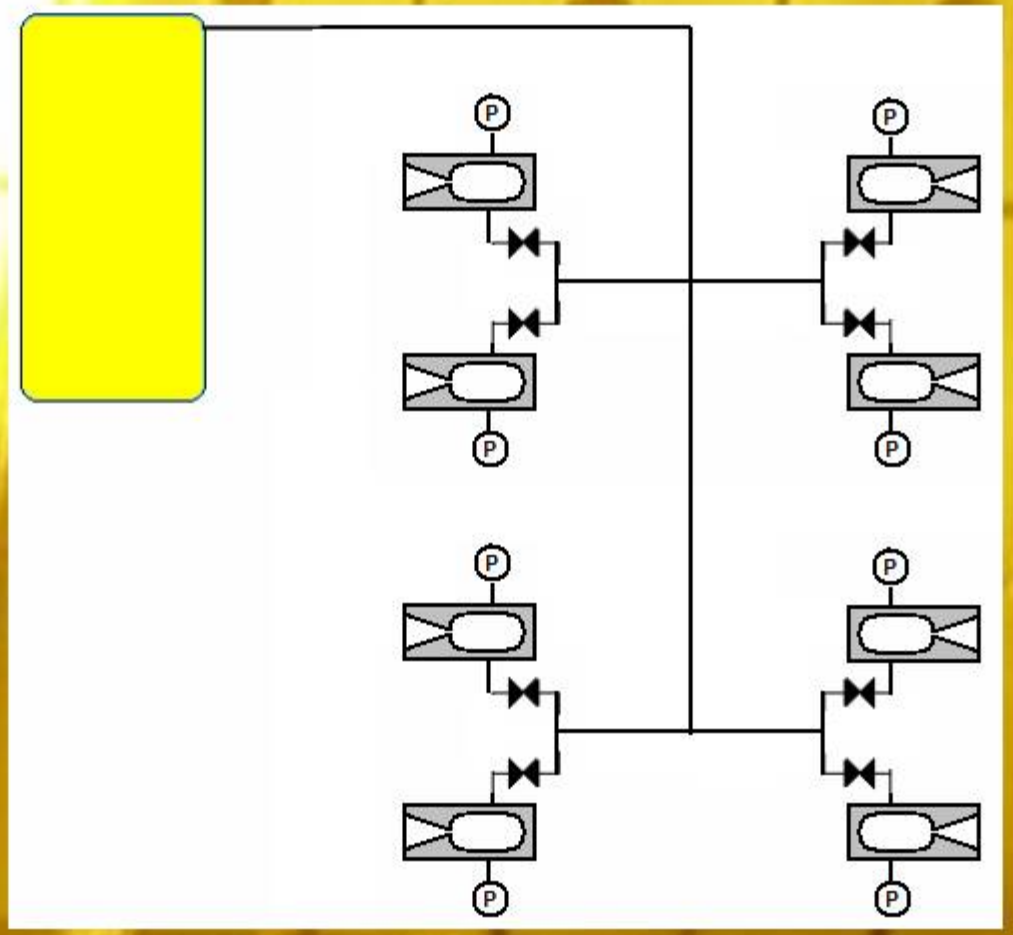
- microthrust
  0.01 – 10 mN
- intensity control
  0-100%
- duration control
  0.1 – 1000 s
- very high number of pulses
  10-1000/orbit
- good Δv
  1 – 100 m/s
- Miniaturized
  0.2 l, 0.2kg

System Architecture and manufacturing-assembly technology selection

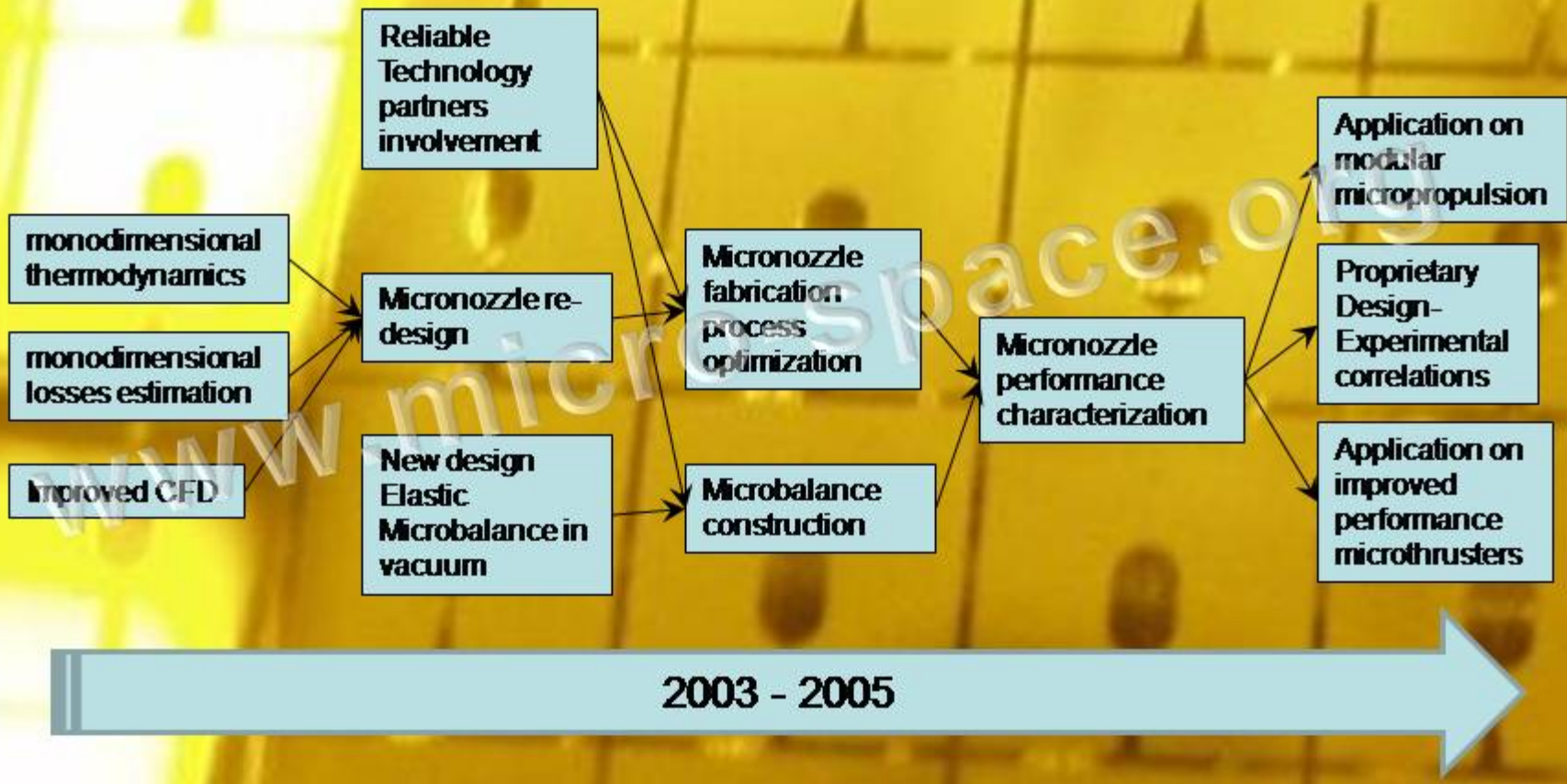
	Monolithic integration on silicon	Hybrid integration of different technologies
Available	Not completely	Yes
Necessary	No	Almost in any case
Sufficient	Not completely	Yes
Economical	No (considering infrastructures and development cost)	Cheapest at the moment
Flexible (easily changeable)	No	Yes
Customizable	Very difficult	Yes
Reparable	No	Yes
Progressively developable	No	Yes
Transferable to other fields	difficult	easy

Our choice

- valve – gas – nozzle based
- modular system
- hybrid assembly



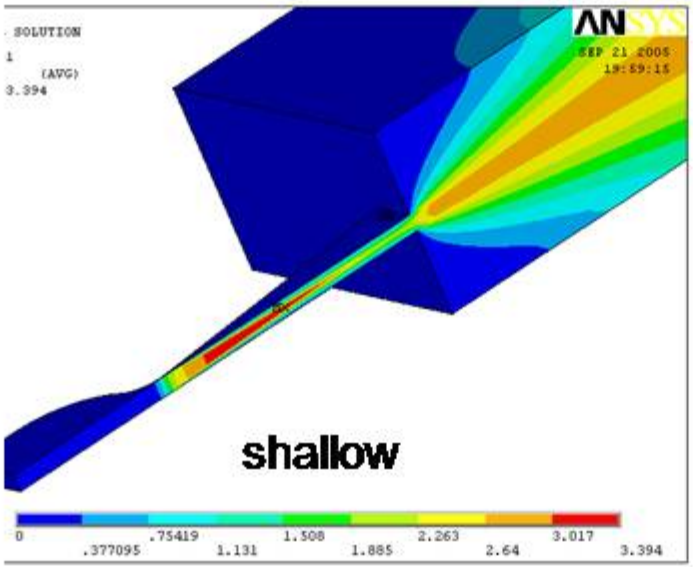
Tactical plan – 2nd R&D iteration for Micronozzle building block: "engineering"

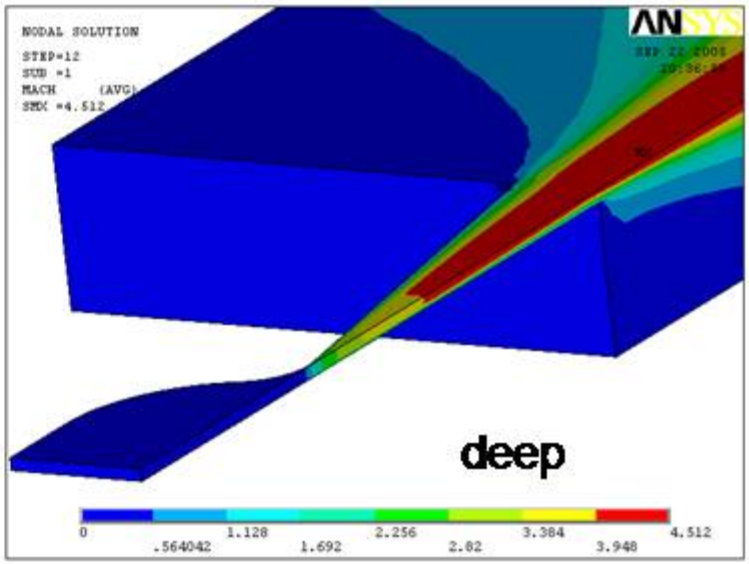


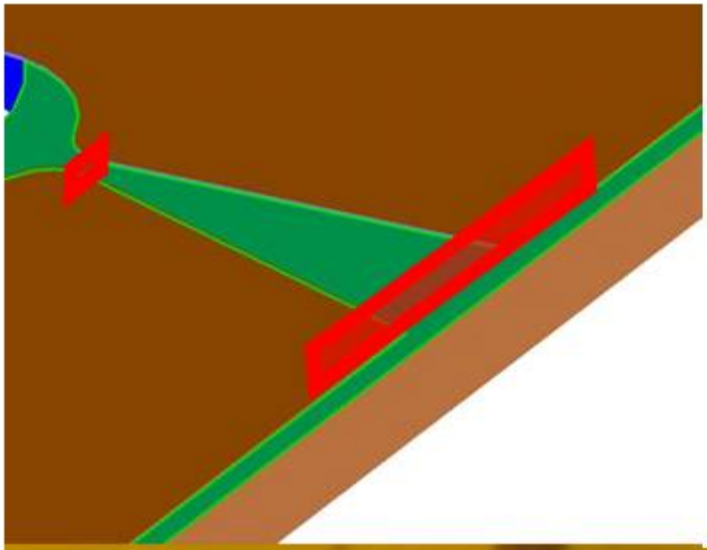
2nd R&D iteration (3 years ago)

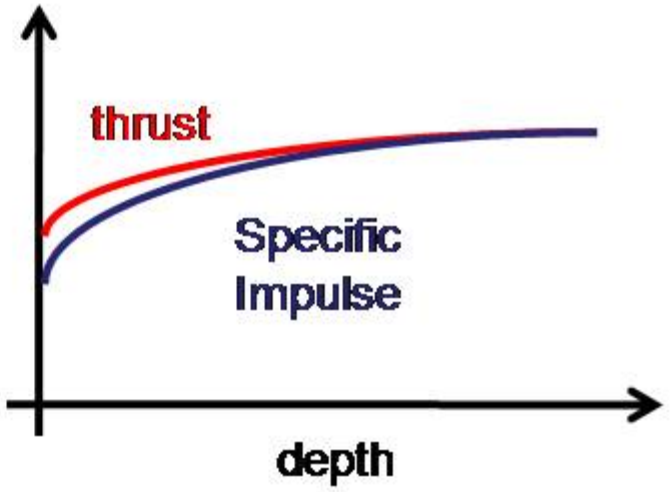
Micronozzle fabrication process optimization

Experimental design correlations









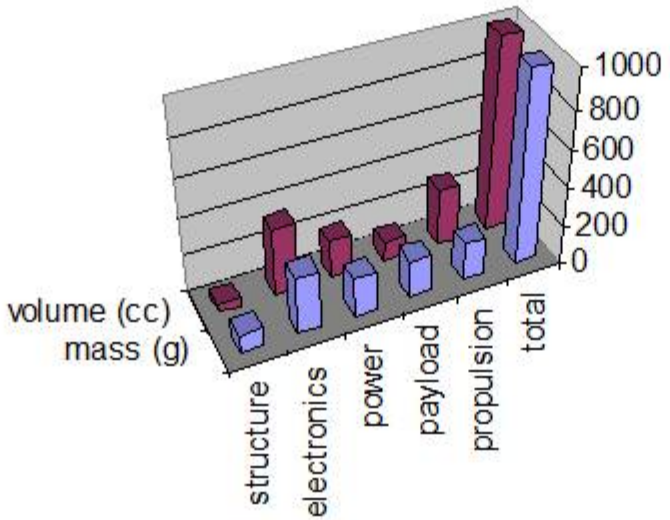
Mass – Volumes and Power budgets for nanosatellites;

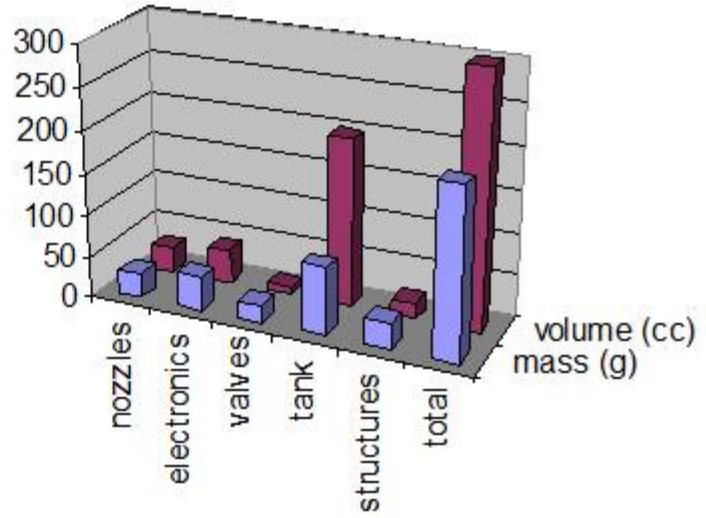
Micropropulsion subsystem

- **200 – 300 cc**
- **200 g**
- **2 W (up to 10W for short time or with deployable solar panels)**

CUBESAT BUDGETS		
subsystem	mass	volume
	g	cc
structure	100	50
electronics	300	350
power	200	200
payload	200	100
propulsion	200	300
	1000	1000

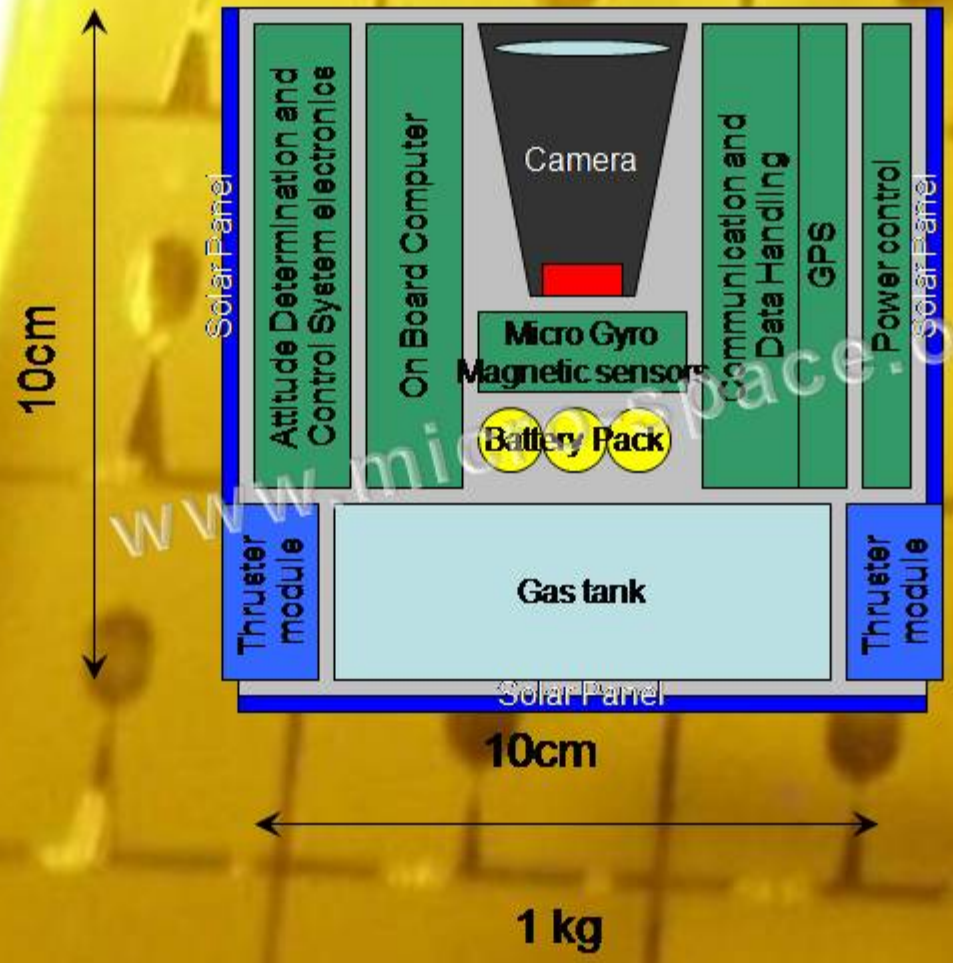
PROPULSION BUDGETS		
element	mass	volume
	g	cc
nozzles	30	30
electronics	40	40
valves	20	10
tank	80	200
structures	30	20
	200	300



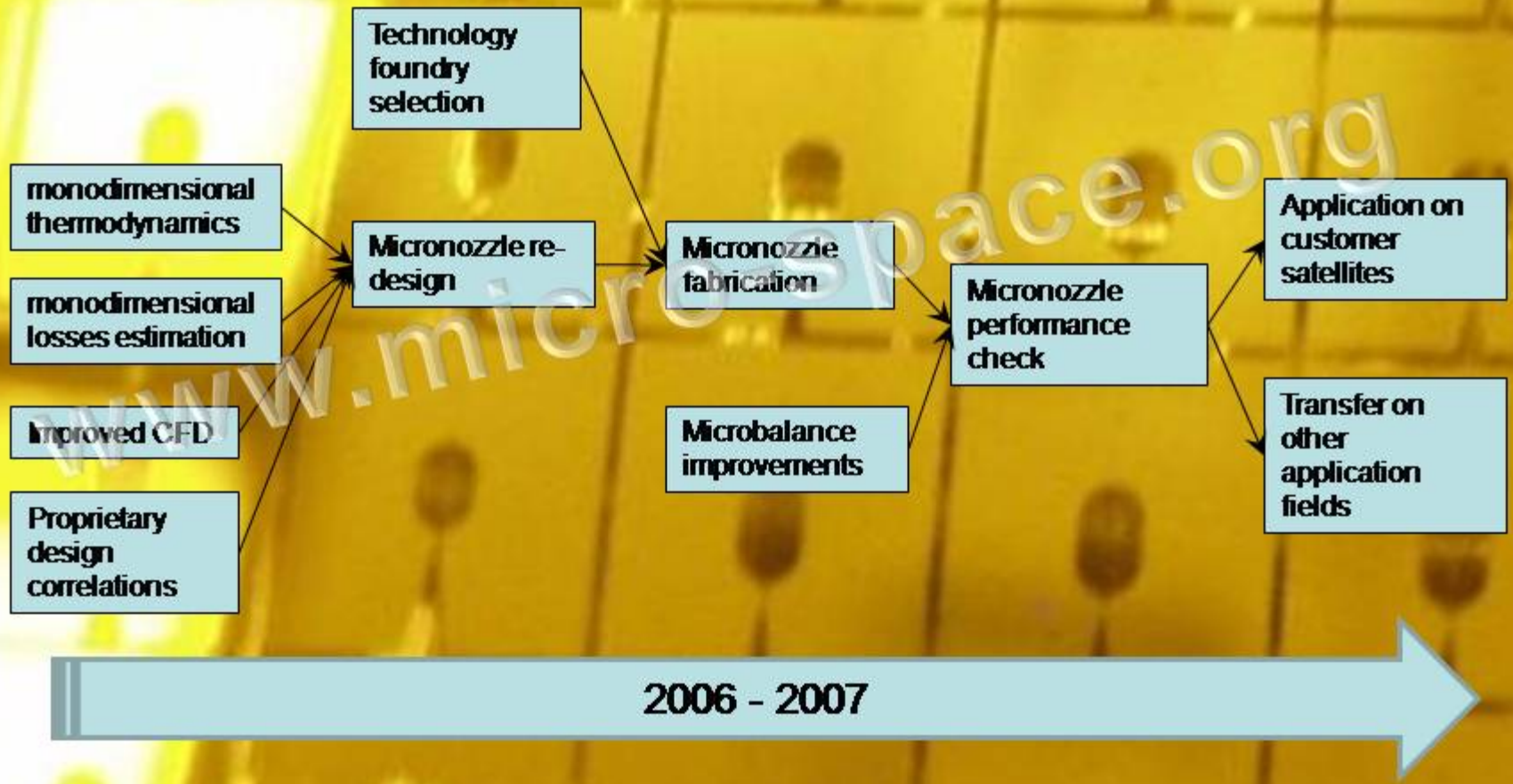


Micropropulsion system impact on Cubesat architecture:

30% of the volume
30% of the mass



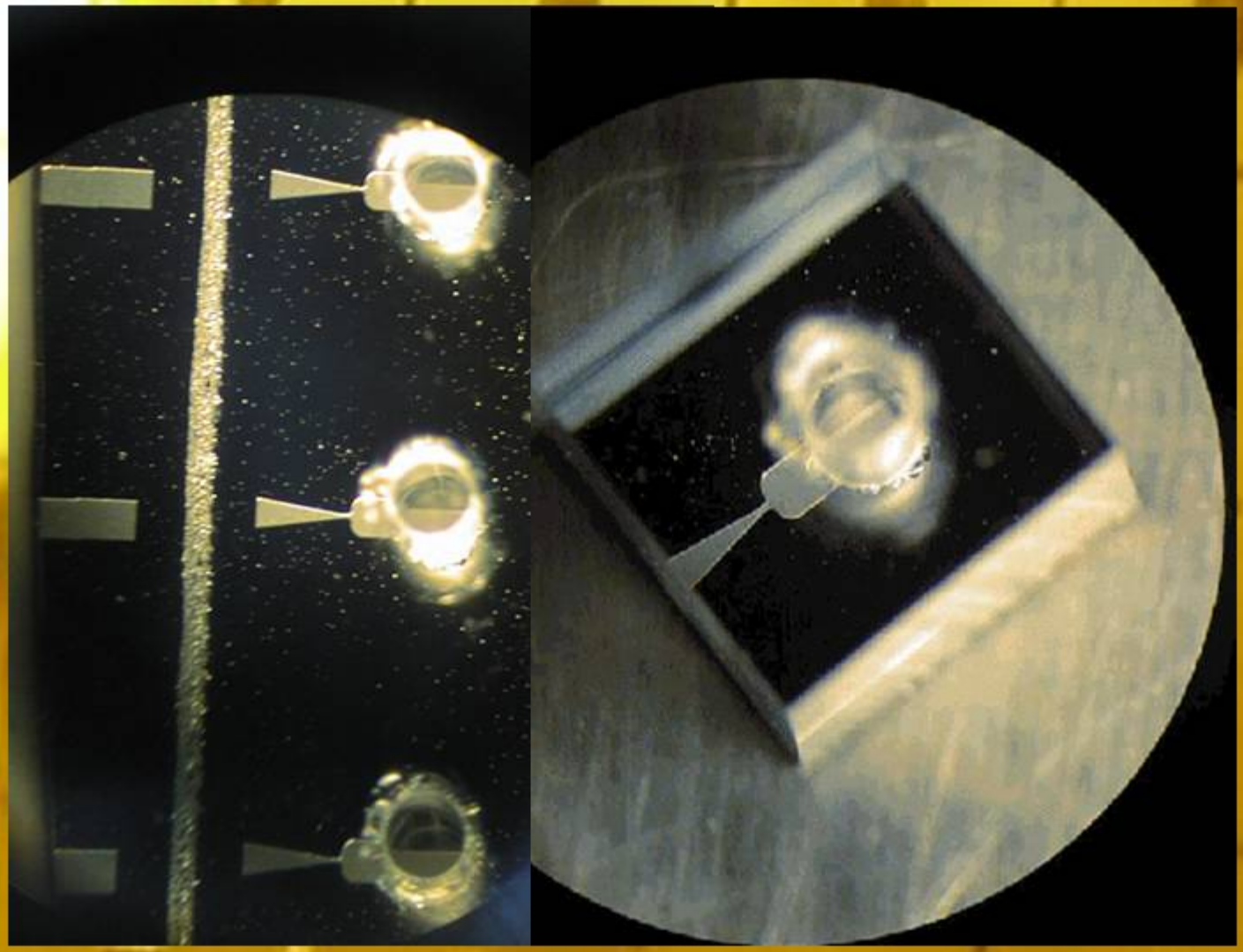
Tactical plan – 3nd R&D iteration for Micronozzle building block: "production"



1st R&D iteration:

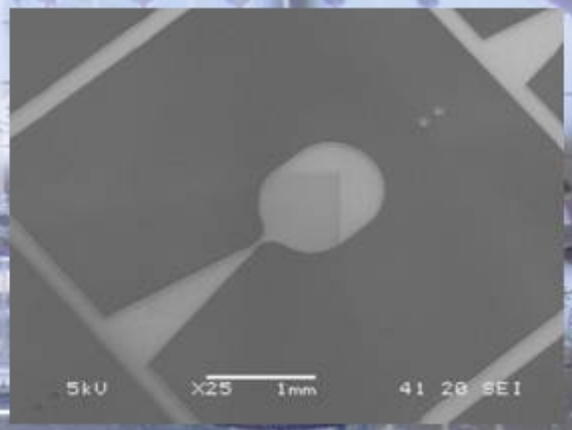
(5 years ago)

Micronozzle fabrication demonstration



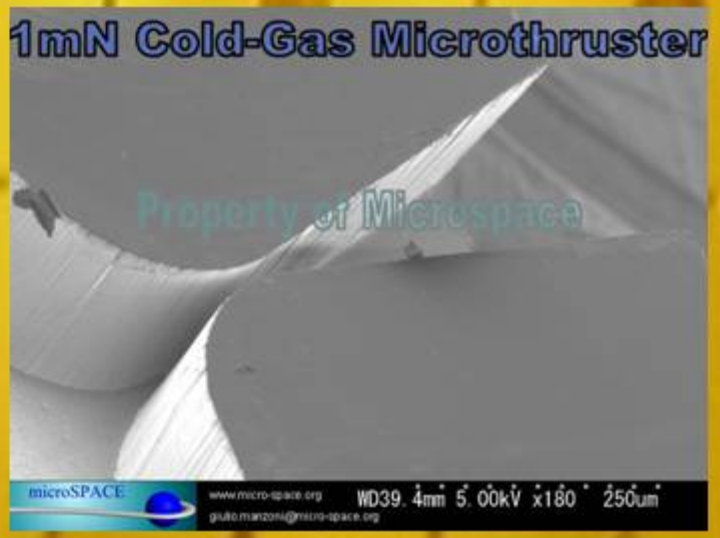
2nd R&D iteration
(3 years ago)

Micronozzle fabrication process optimization



2nd R&D iteration (3 years ago)

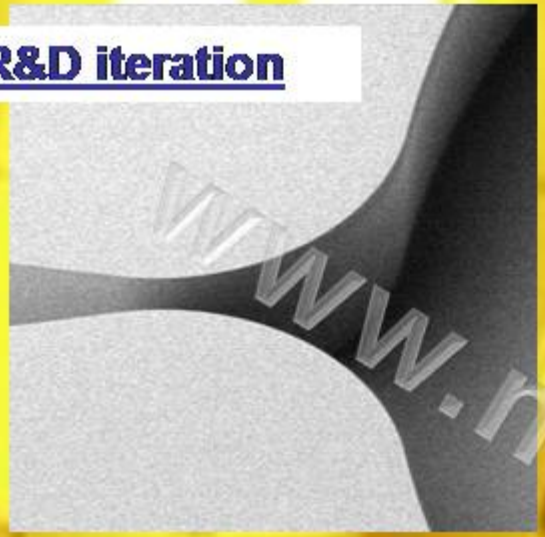
Micronozzle fabrication process optimization

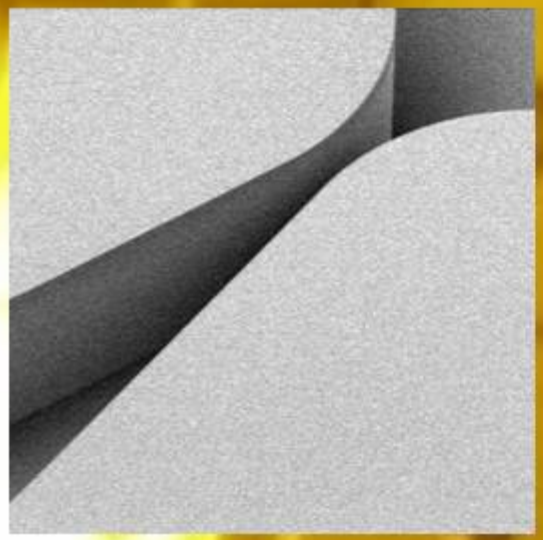


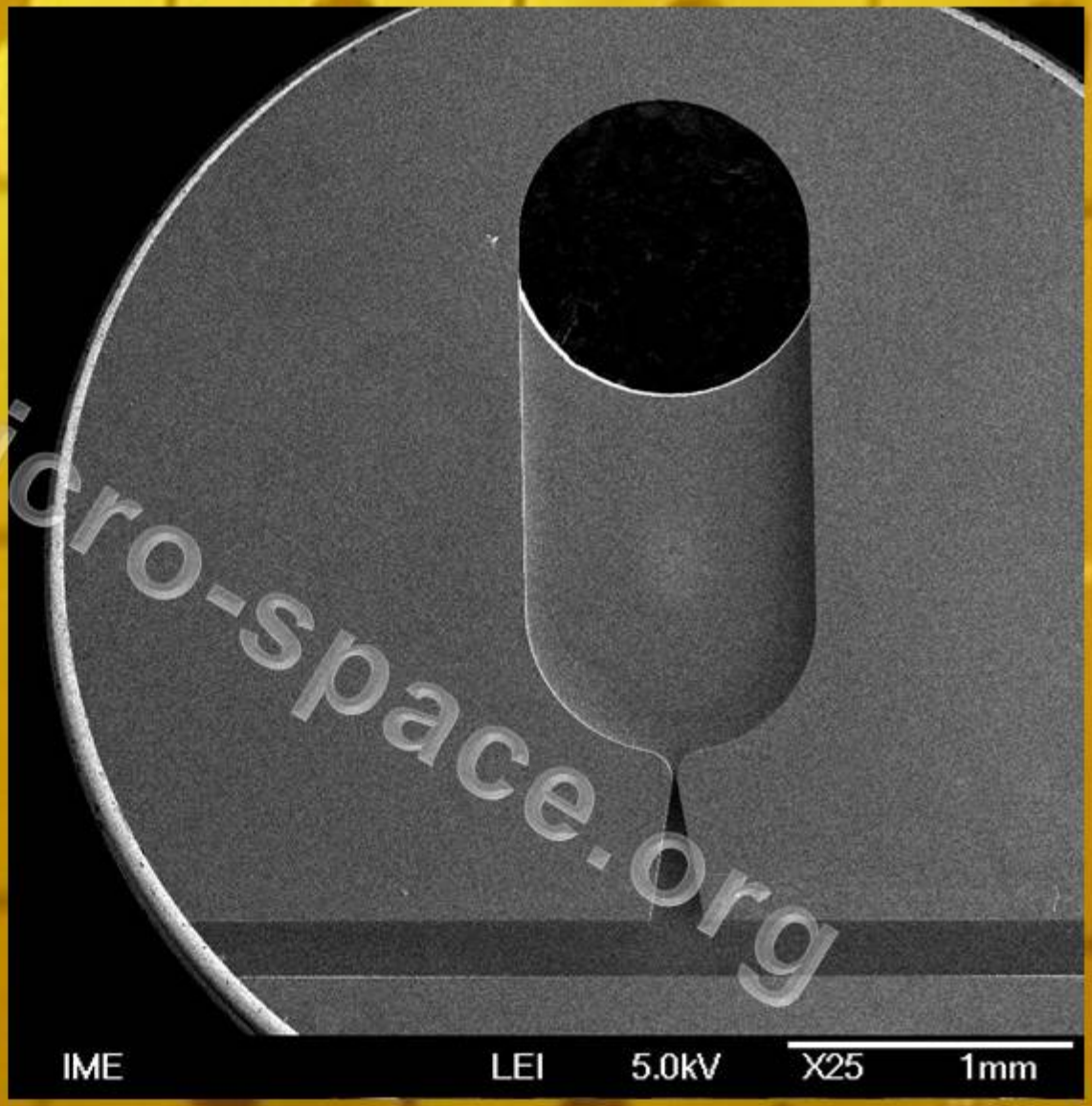
3nd R&D iteration
(1 year ago)

Micronozzles production

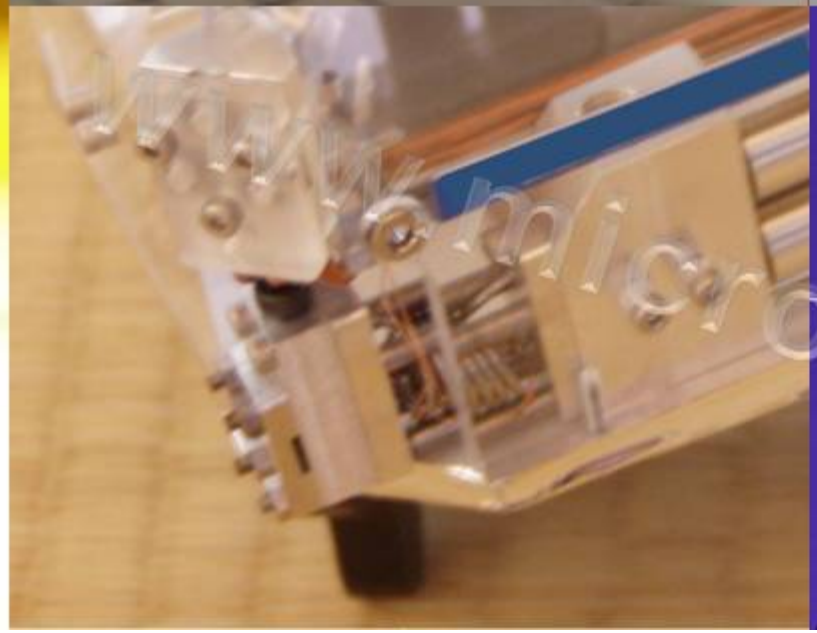
3nd R&D iteration



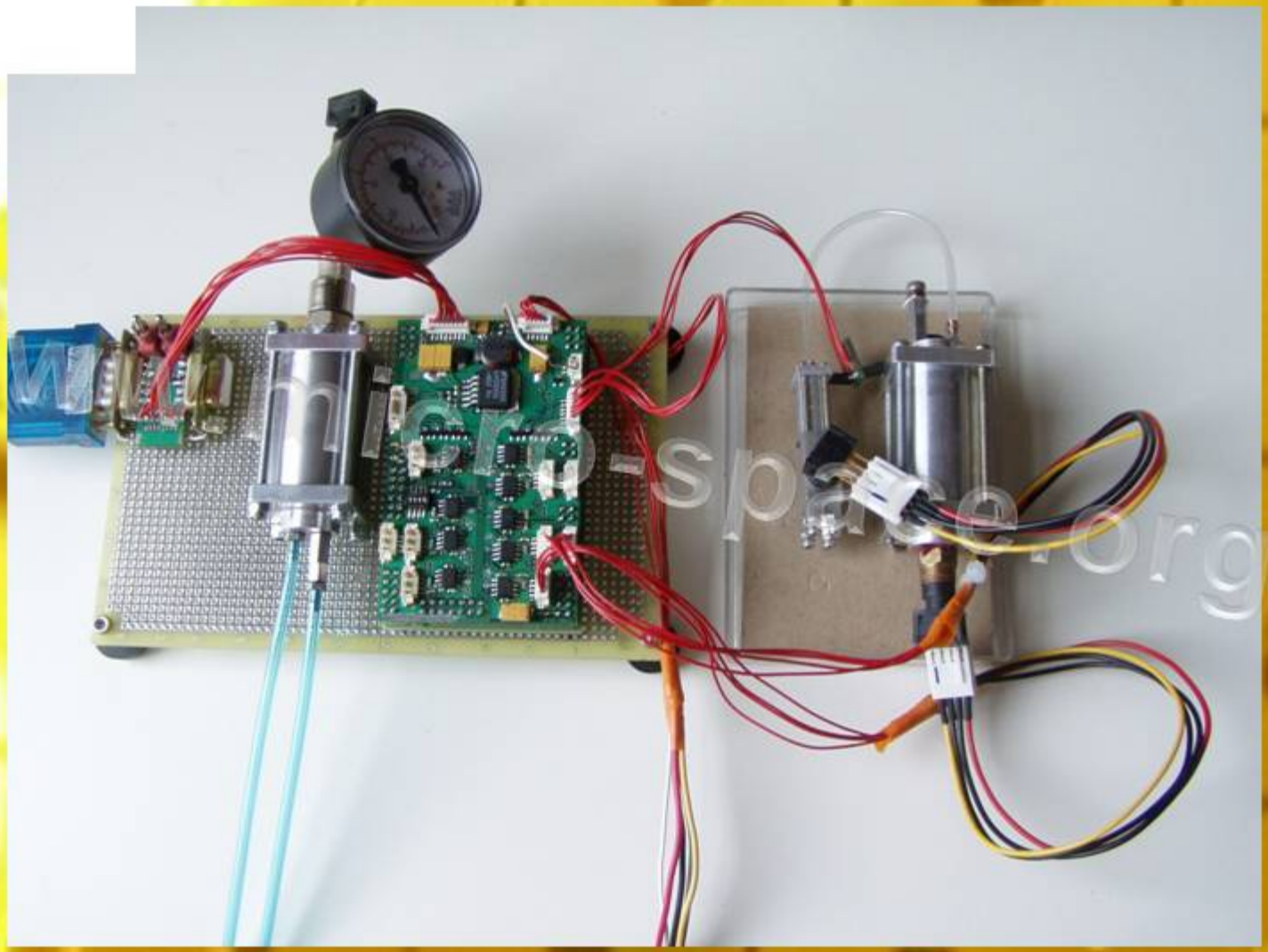




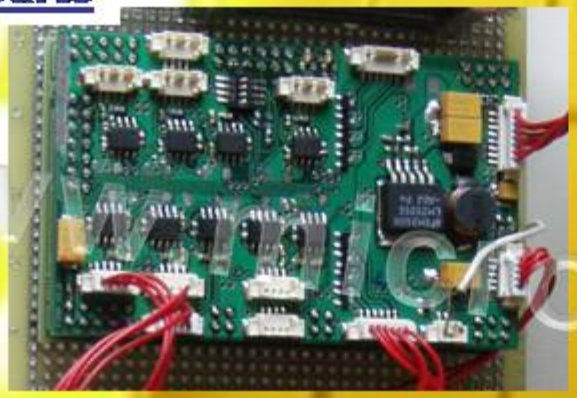
Microthruster Family



System breadboard



Other system parts



Microthruster family

- modular elements growth
- continuous learning process
- Cubesat suitable
- easy performance customization
- affordable R&D
- affordable price

engine	Cold-Gas	Warm-Gas	Vaporizing	Bipropellant
Thrust (mN)	0.01 - 10	0.01 - 10	0.1 - 10	0.1 - 10
Specific imp. (s)	30 - 50	60 - 100	60 - 100	100 - 200
Δv (m/s)	1 m/s	2 m/s	200 m/s	300 m/s
mass	20g	35g	40g	60g
Volume (tank excl.)	5cc	9cc	10cc	15 cc
Options	Up to 8 nozzles; Press. Feed-back	1, 2, 3 or 4 nozzles; Press. Feed-back	1 nozzle; Press. Feed-back	1 nozzle; Press. Feed-back; Mix control; Heat regeneration
status	Mission ready	Mission ready	Qualification	Prototyping: testing

Complete Micropropulsion systems:

- ✓Cubesat, nanosatellites, microsatellites
- ✓Modular
- ✓Miniaturized
- ✓Customized
- ✓Qualified
- ✓Affordable
- ✓Ready

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Microspace S.r.l (Italy)
Microspace Rapid Pte Ltd (Singapore)
Nanoglobe Inc. (Japan)

And, North Asia Representative:
Astro Research Co. (Japan)

ASTRO RESEARCH

Contact:
Giulio.manzoni@micro-space.org

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