Development of MEMS based EP

TNO, NanoSpace, EPFL, QMUL, SystematIC

CANEUS / ESA MNT Workshop 2010

TNO | Knowledge for business

Berry Sanders, Business Developer

What do we want to achieve

- To provide small European missions using micro and nano satellites with the possibility to conduct high delta V manoeuvres in order to perform exiting science and space applications

- This goal can be accomplished by developing a miniaturised high Isp propulsion system that is
  - highly miniaturised
  - modular
  - simple and affordable
  - plug and play

- Benefits
  - Lower cost and faster development for missions
  - Space science and applications become more accessible

Feasibility study

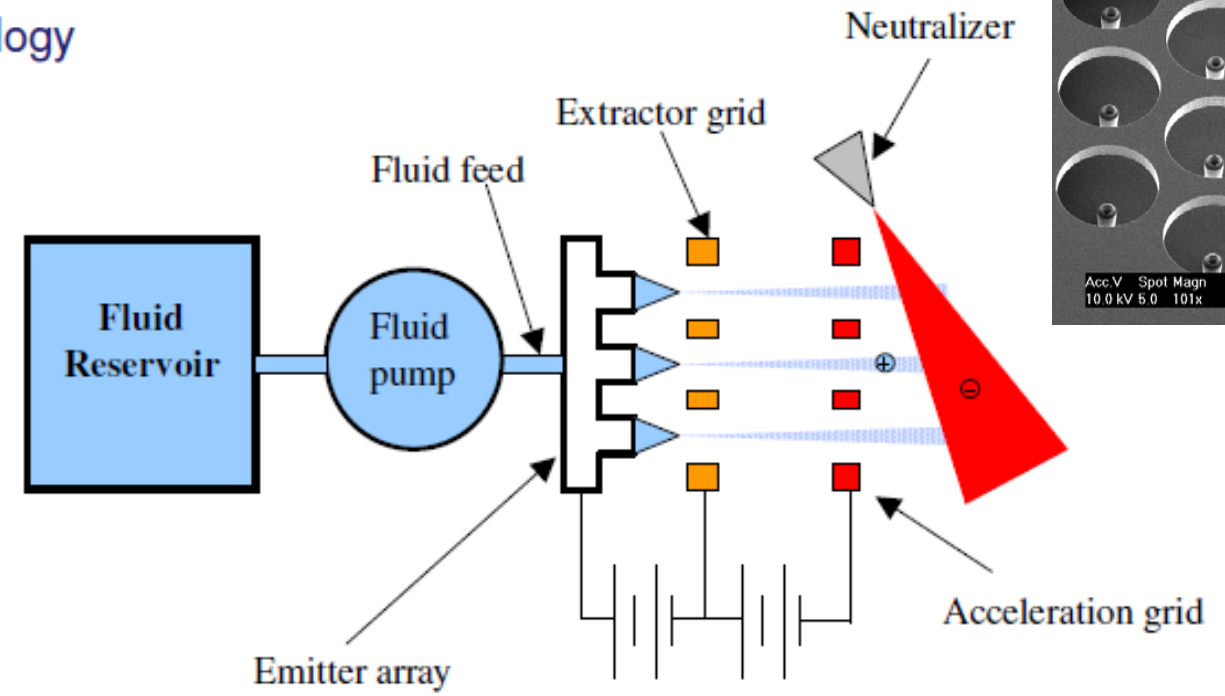
- A team consisting of EPFL (CH), Nanospace (SE), TNO (NL) QMUL (UK) and SystematIC (NL) have investigated possibilities for EP Miniaturisation and started its development

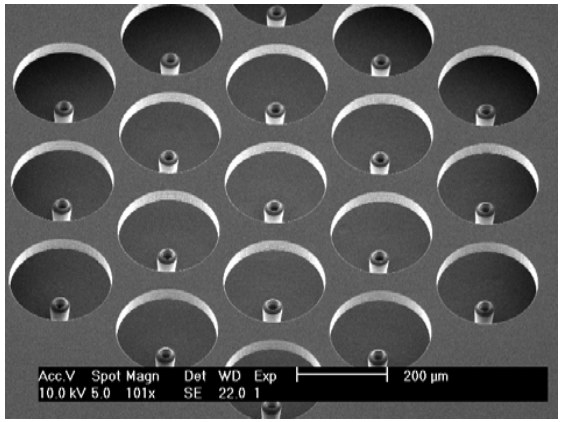
- The Colloid thruster offers a very good potential for miniaturisation
  - Size independent physics
  - Adjustable working points between high thrust and high Isp
  - Medium to low voltage (max 3 kV)
  - Components can be easily designed in MST

- The technology can be applied to a broad range of missions and applications

Colloid thruster technology

Colloid thrusters have the highest potential of miniaturisation and use of MEMS technology





Electrostatic acceleration of charged species for propulsion

Droplets, solvated ions or a mixture of them

Assessment of potential missions

Parameter	CubeSat 1U	CubeSat 3U	NanoSat 8 kg	MicroSat 27 kg	MicroSat 64 kg	MicroSat 125 kg
ACS						
Bang-bang system	✗	✗	✓	✓	✓	✓
Wheel unloading	✗	✗	✓	~	✗	✗
Low perturb. compensation	N/A	N/A	N/A	N/A	✓	✓
Orbit control and transfers						
Drag make-up*	✓	✓	✓	✓	✓	✓
FFM*	✓	✓	✓	✓	✓	✓
De-orbiting*	✓	✓	✓	✓	✓	✓
Orbital debris*	✓	✓	✓	✓	✓	✓
LEO ->MEO*	✓	✓	✓	✓	~	~
GTO ->Moon*	✓	✓	✓	✓	~	~

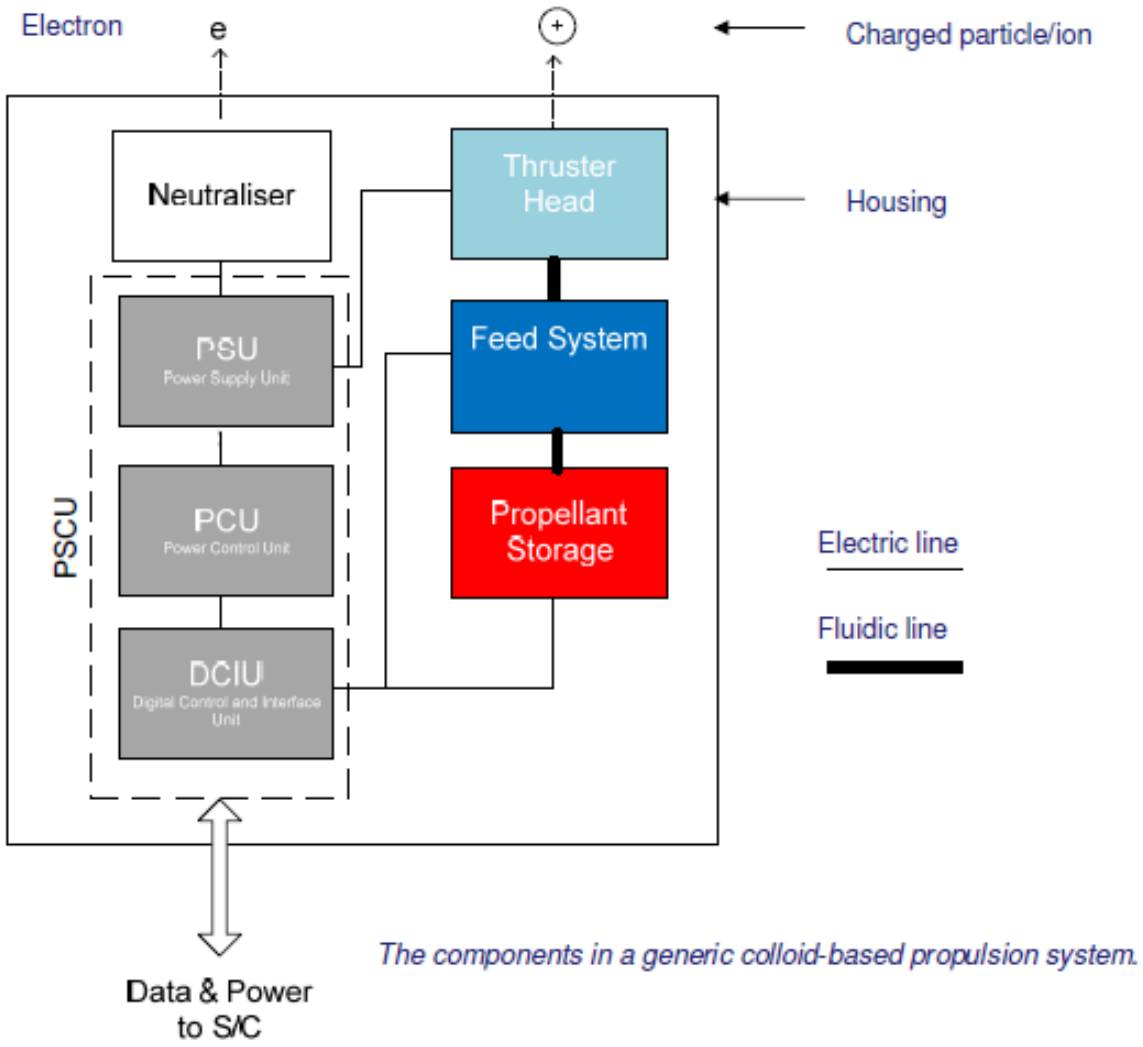
*Continuous low-thrust scenarios

Can be done with additional power

Ideas for potential missions

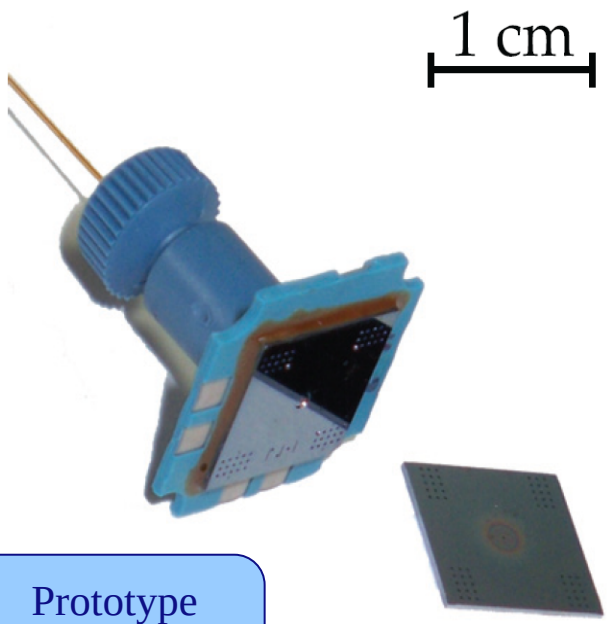
- OLFAR
  - A swarm of microsatellites conducting radio astronomy from a moon orbit
  - MST-EP will be used for GTO Moon transfer
- Clean-mE
  - A Space Debris removing microsatellite
  - Attaches itself to space debris and de-orbits it
- Cubesat OPM
  - Propulsion module to bring a cubesat to its operational orbit after a piggy-back launch
  - Low cost launch and still reaching a dedicated orbit

Colloid thruster system design

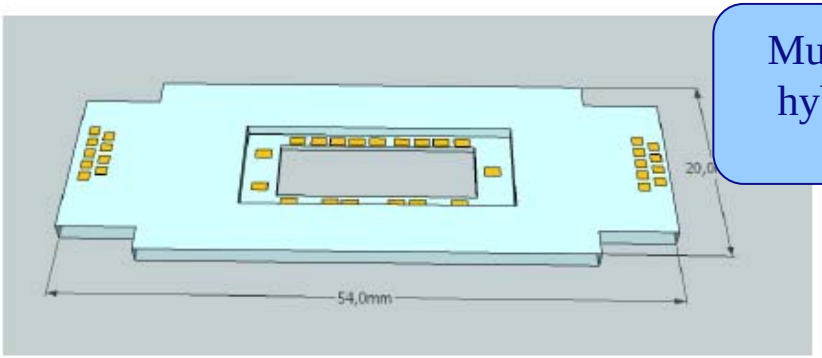


The components in a generic colloid-based propulsion system.

Thruster head design

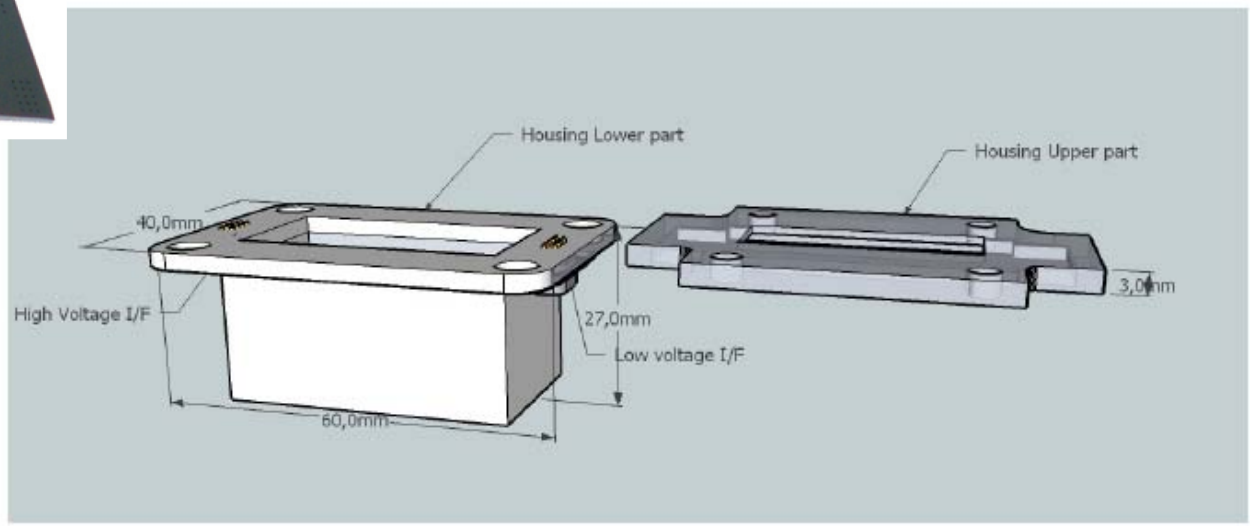


Prototype thruster chip



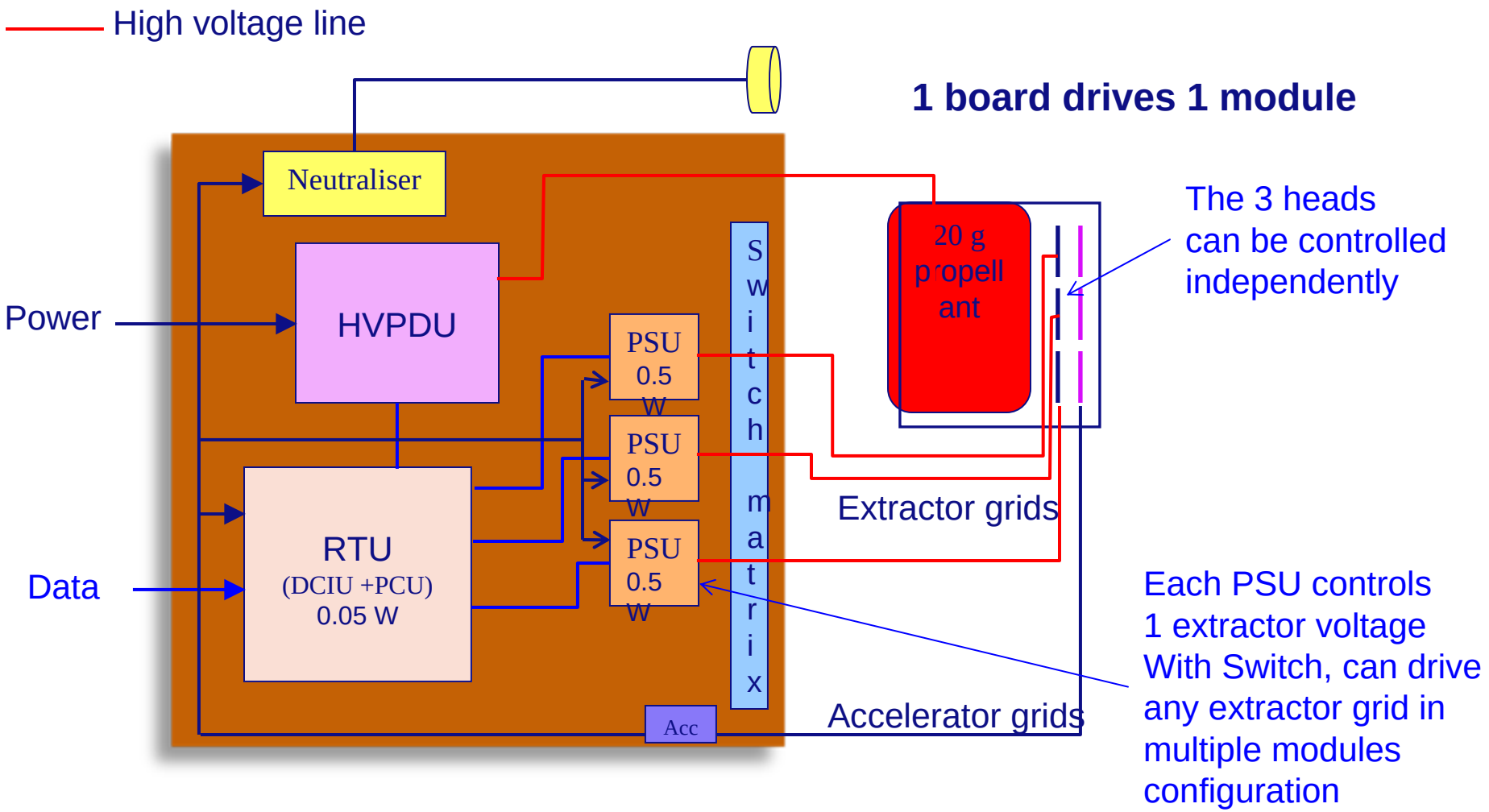
Multi layer hybrid I/F chip

LTCC substrate for mechanical and electrical I/F

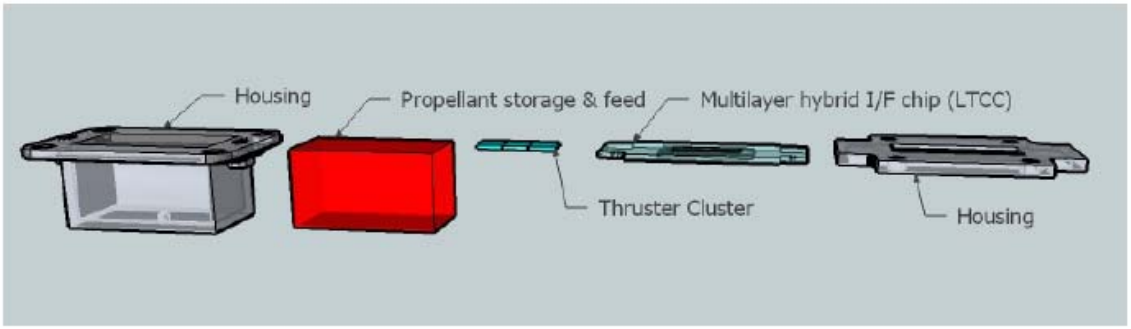


Housing

PCU conceptual design



Preliminary design MEMS based EP



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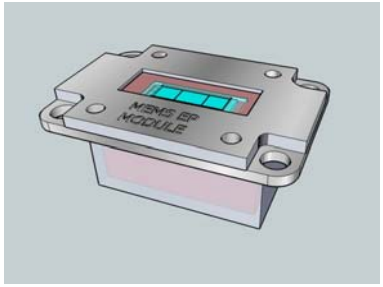
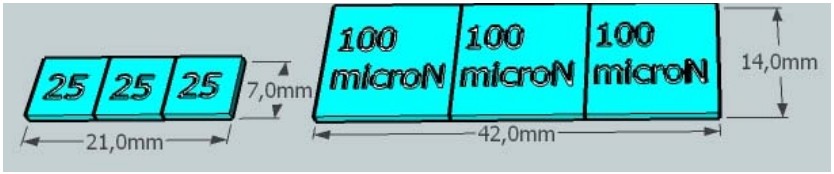
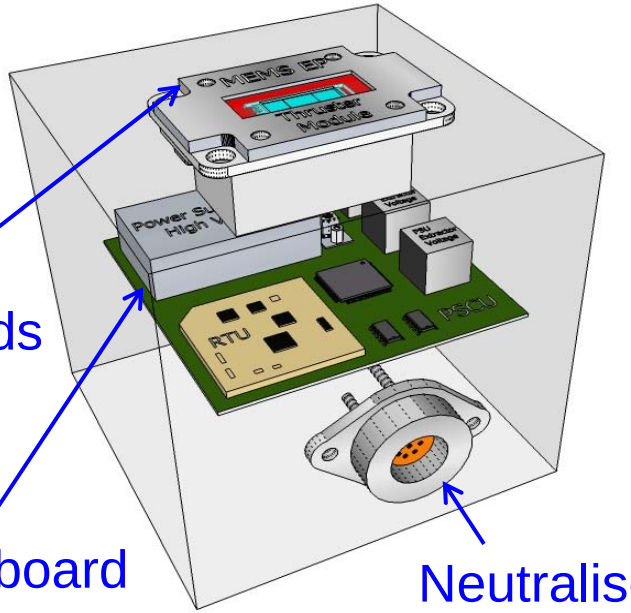




MEMS EP module
includes cluster of 3 heads
7 x 21 = 147 mm2



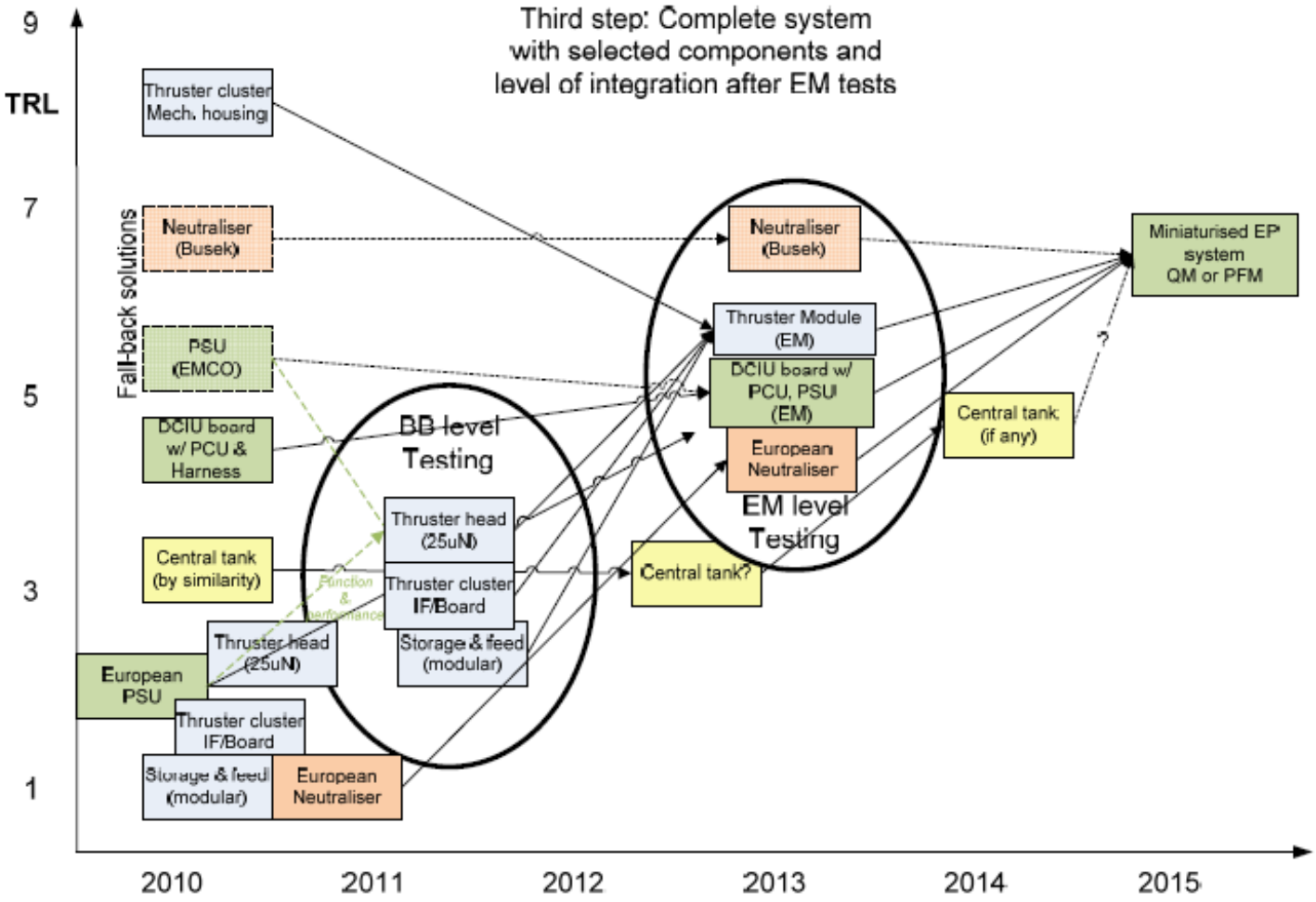
Power and control board

Neutraliser

Developement programme

- Feasibility study has been completed under ESA contract (TRL 3)
- The same team will start the Microthrust programme (FP-7 Space)
  - EM will be developed and tested with functional subsystems
  - Microthrust will run between 2010 and 2013 (TRL 5-6)
- The follow on step is to develop a flight demonstration prototype to be ready in 2015 (TRL 7)
- First flight units could be delivered in 2016 (TRL 8-9)
- Challenges:
  - miniaturised space qualified HV units
  - miniaturised neutraliser
  - Life time testing

Road map


Third step: Complete system with selected components and level of integration after EM tests
TRL
9
7
5
3
1
Fall-back solutions
Thruster cluster Mech. housing
Neutraliser (Busek)
PSU (EMCO)
DCIU board w/ PCU & Harness
Central tank (by similarity)
European PSU
Thruster cluster IF/Board
Storage & feed (modular)
European Neutraliser
Thruster head (25uN)
Function & performance
BB level Testing
Thruster cluster IF/Board
Storage & feed (modular)
Neutraliser (Busek)
Thruster Module (EM)
DCIU board w/ PCU, PSU (EM)
European Neutraliser
EM level Testing
Central tank?
Central tank (if any)
?
Miniaturised EP system QM or PFM
2010
2011
2012
2013
2014
2015

Conclusions

- Miniaturized propulsion can enable small and nano satellites to conduct missions for which now large satellites are needed
- The first preliminary study showed the feasibility of a Miniaturized and Modular MST Electric propulsion system using Colloid technology
- Between 2010 and 2013 the different subsystems will be developed in the FP-7 Microthrust project. In 2013 a fully functional EM will be tested
- The whole system could be flight tested in 2015 and operational applications can start in 2016
- This development will have interesting spin-offs like a miniaturized neutralizer and miniaturized HV components
- For more information: www.microthrust.net