PIXE 2015: PocketSpacecraft.com
Integrated exploration Environment update

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4th Interplanetary CubeSat Workshop
iCubeSat 2015

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• Founded 2010
• Ops in China, IoM, UK & USA
• Creates, encourages, funds, manages or otherwise supports more than two dozen open source open access space exploration infrastructure projects
• Seven flight projects
• Collaborate with academia, enthusiasts, government, industry and non-profits
• >300 volunteers, >30 countries
goal

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$>10^1 \approx 5000 \text{km radius}$
$>10^2 \approx 100 \text{ km radius}$
$>10^4 \approx 20 \text{ km radius}$
$>10^6 \approx 0.5 \text{ km radius}$ in asteroid belt alone
pocket spacecraft
a spacecraft that an individual can afford to buy, launch and operate with little or no technical expertise

personal space age
the era of exploration of space by private individuals for science, general interest and profit
- science goals
  - be useful, be responsible
  - work within existing frameworks and systems where possible
  - enable many of the >95% of missions not down selected
- consumer goals
  - support $10^6$ participating explorers
  - video game size quantum of exploration
  - instant gratification and mass customisation
  - appeal to everyone from collectors to citizen space engineers
- easy to use for everyone
  - point and click/touch design, collaboration and autonomous operation
- sustainable
  - fun, interactive, immersive for years or decades
  - spread risk, be comfortable not knowing where it may lead
  - legal, honest, decent and truthful
  - make affordable - crowd source, fractionate and automate everything
- symbiotic and respectful
  - scientists need explorers, explorers need scientists
  - everyone needs engineers
  - all skill levels can contribute something – apps/money both ways
• Crowd sourced funding via 315 Kickstarter backers
  – 67 @ $25
  – 67 @ $75
  – 88 @ $300
  – 26 @ $1000
  – 0 @ $5000
  – 1 @ $10000

• NASA ELaNa 5 launch April 2014

• Student labour

• Reuse existing open source systems

• Very inexpensive

• Very short lived
Pocket Spacecraft
TF-SLR Scout prototype v0.4

Solar cell
CIGS or SpectroLab TASC

SoC lapped to <50µm
TI CC430F5137IRGZ die

Printed passives (RCL)
e.g. Cabot CCl-300 ink

Antenna bustle/actuator
NiTi memory metal

Custom graphics
Laser marked

<8cm
<3.2"

Graphics courtesy: JA / PocketSpacecraft.com
Resistance:

- ‘They will never work’
- ‘You can’t do anything useful’
- ‘They are just for students’
- ‘You can’t do real science’
- ‘You can’t fit real instruments’
- ‘You can’t do useful imaging with such small apertures’
- ‘They don’t have enough power’
- ‘They’re unreliable’

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“It’s hard to imagine [ChipSats and TF-SLRs] will be capable enough, but that’s exactly what people said about CubeSats.”

Therese Moretto Jorgensen, Program Director, National Science Foundation

*Nature* 508, 300-301 (17 April 2014)
Communications and navigation

LOFAR Configuration
Observation: PS86X1/O2
Start: T+93:00:00:00
Duration: 00:10:12:00
Channel(s): 235
Centre: 145.8984375 MHz
Mode: Complex Voltage
Sub-mode: Fly's eye
Reference: 20141019/7.1.7.3.19

Antenna
Network link
Data centre

SE607HBA - Onsala
3370272.092, 712125.596, 5849990.824
57.39875746, 11.93098901, 41.356
Delay compensation: OFF

CS002LBA - Superterp
3826577.462, 461022.624, 5064832.526
52.91511897, 6.86983284, 49.350
Delay compensation: ON

CEP1 - Groningen

DE604HBA - Potsdam-Bornim
3796380.254, 877613.809, 5032712.272
52.43785922, 13.01648194, 75.843
Delay compensation: OFF

AMS-IX - Amsterdam

DE605HBA - Juelich
4005681.407, 450996.304, 4926457.940
52.91511897, 6.86983284, 49.350
Delay compensation: OFF

DE601HBA - Effelsberg
4034101.901, 487012.401, 4900230.210
50.52260408, 6.88365956, 360.993
Delay compensation: OFF

DE603HBA - Tautenburg
3940296.126, 816722.532, 4932394.152
50.97939457, 11.71012829, 376.426
Delay compensation: OFF

DE602HBA - Unterweilenbach/Garching
4152568.416, 828788.802, 4754361.926
50.37934787, 11.7126745, 378.840
Delay compensation: OFF

PS-DC44A - Bristol

UK608HBA - Chilbolton
4008462.280, -100376.948, 4943716.600
51.1435426, -1.43445876, 177.05
Delay compensation: OFF

FR606HBA - Nançay
4324017.054, 165545.160, 4670271.072
47.37552429, 2.19250034, 182.091
Delay compensation: OFF

Graphics courtesy: ASTRON, JA, LuxSpace, STFC
• Planetary protection (to Category IVc)
• Spacecraft can be launched speculatively
• Potential clashes with existing frameworks (e.g. amateur vs scientific vs commercial)
Challenges – number of spacecraft

- 3881 payloads catalogued on orbit by U.S. Space Surveillance Network
- KickSat proof of concept low earth orbit mission launched 2014: >100 spacecraft
- Pocket Spacecraft interplanetary proof of concept mission 2015/16: >1000 spacecraft
- Potentially >1 million TF-SLRs to come over next two decades
- Number of spacecraft printed per mothership may be unknown at launch and could vary by orders of magnitude
• Current regulatory fees for spacecraft that can profitably be manufactured, launched and operated for less than $99 each can be disproportionate (> $10,000 per spacecraft)
• License application fee (no guarantee of success): UK: £6,500-£13,000 per mission (£0 in China, Spain, USA, etc.)
• €60 million third party insurance cover per mission: UK: €600,000 per year indefinitely (£0 in China, Spain, USA, etc.)
• Pocket Spacecraft interplanetary proof of concept mission has spacecraft backed by participants from >40 countries

• Spacecraft could be designed, manufactured, launched, deployed, managed or operated by different children and adults with multiple citizenships with ownership changing at every step and over time
Where do you want to explore today?

michael@PocketSpacecraft.com
@mySpacecraft

* if your question is about an open source project:
  - no restrictions

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