Let's talk SmallSat:
Thoughts on Future Opportunities for Small Satellites

"Small Satellites are Technology Miracle Boxes!" (Hans-Peter Roeser, 1949-2015)

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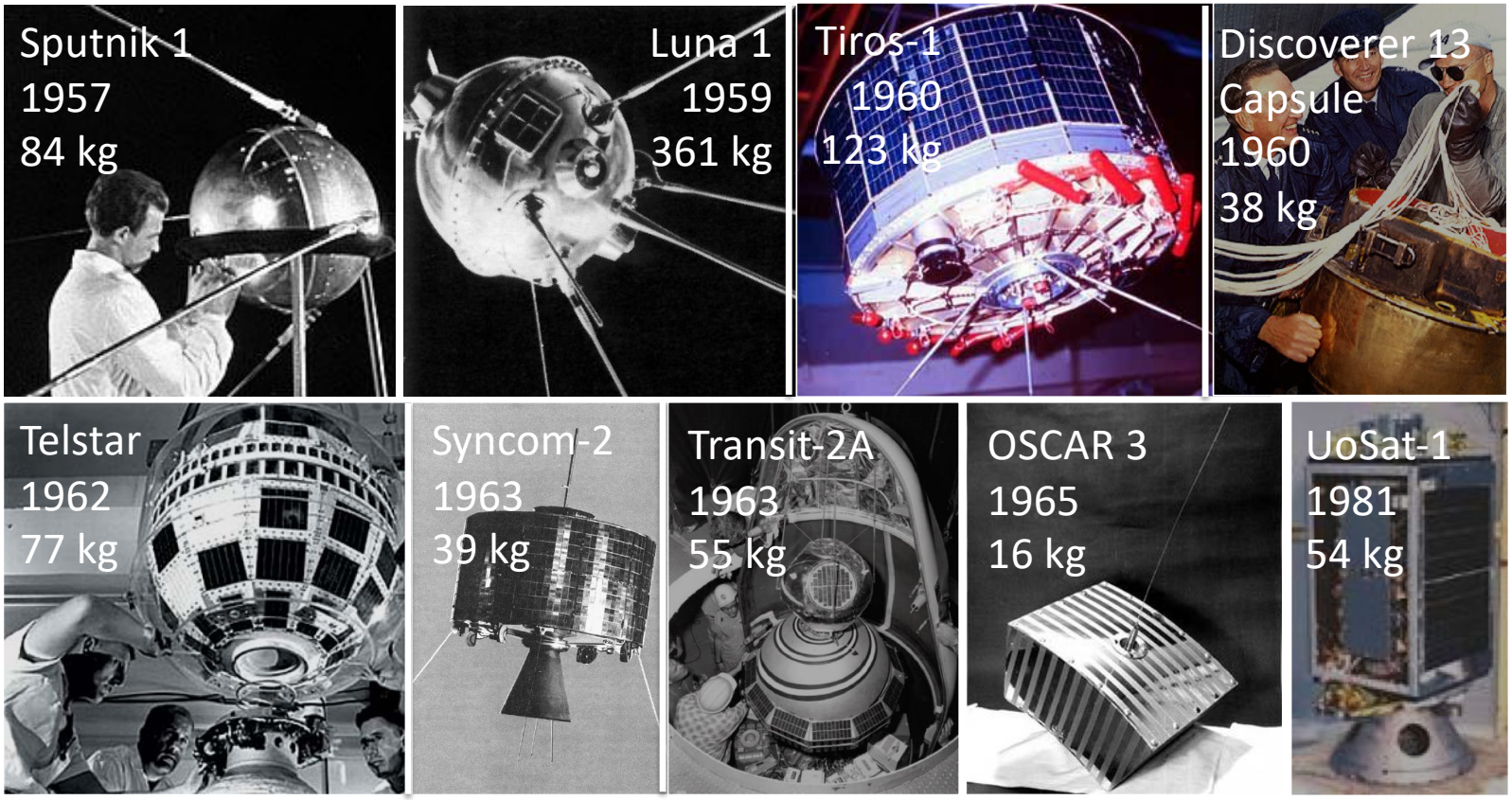
SpaceLab – University of Cape Town, South Africa

Image: US-DARPA

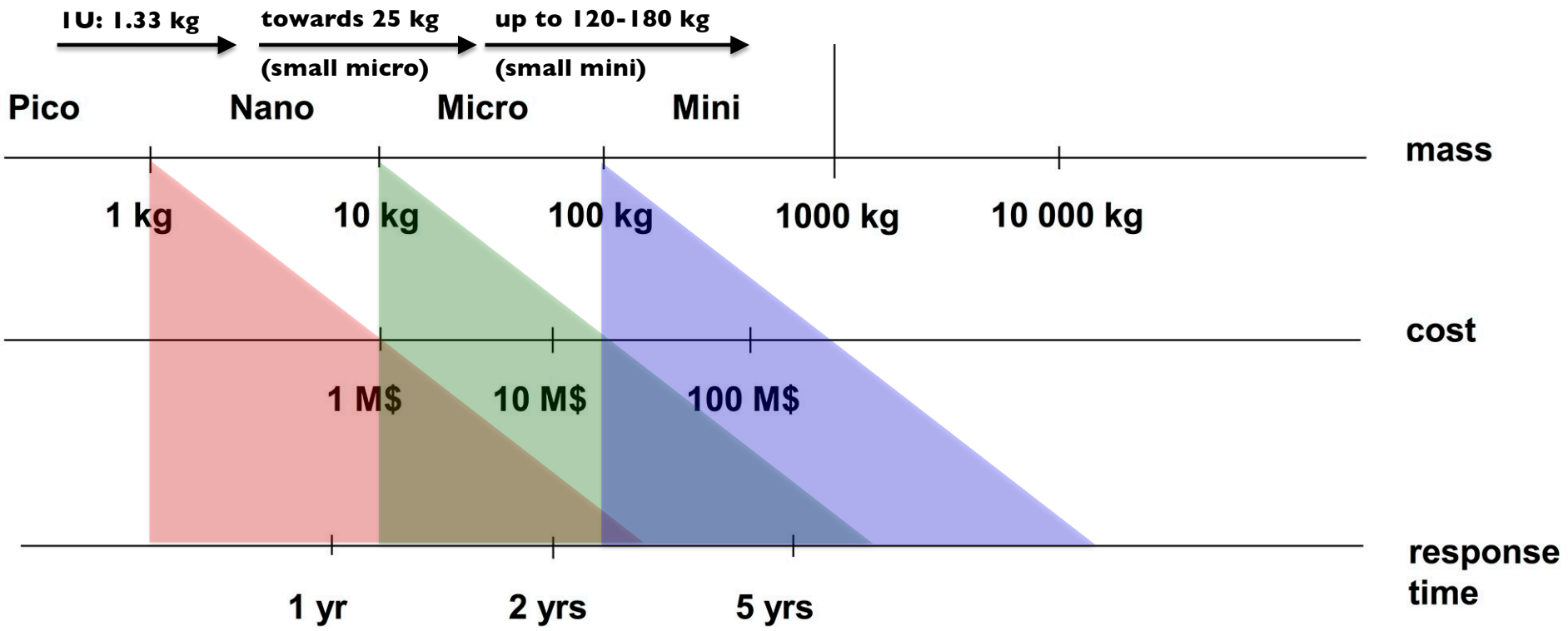
www.baylor.edu/casper

It all started with Small Satellites



Source: NASA, SSTL, Wikipedia

Small Satellites vs. Large Satellites?

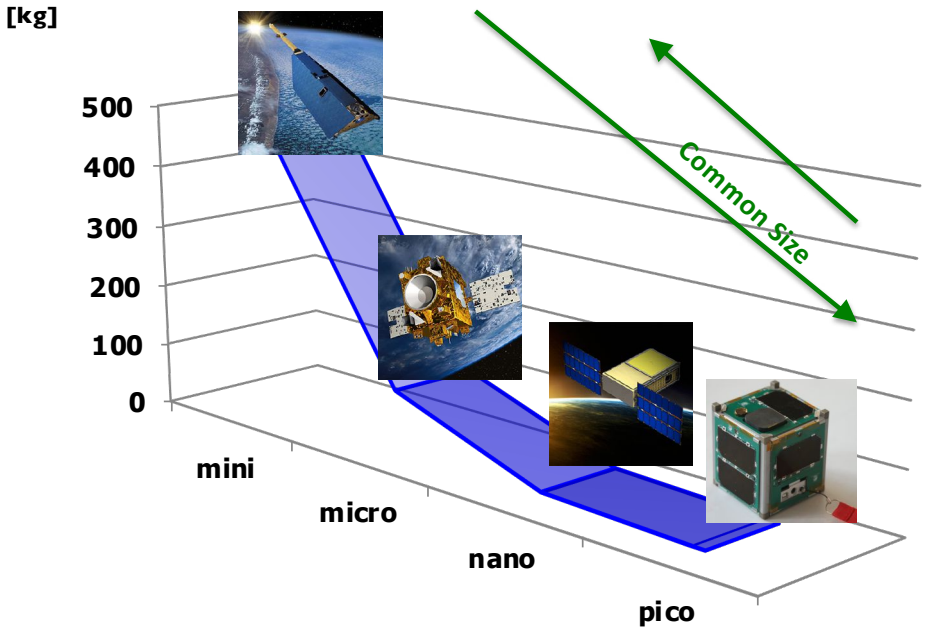


Based on: Sandau, R.; Brieß, K.; D'Errico, M. (2010): DOI: 10.1016/j.isprsjprs.2010.09.003.

Small Satellites: An IAA Perspective

Trends observed by the IAA Permanent Committee on Small Satellite Missions:

- Increase in number of spacecraft (multi-satellite missions, etc.)
- Increase in number of space-faring countries:
  40 by 2000, 90 by 2019
  maybe 100 by end of 2020?
- After a reduction in size (with cubesats since 2003) now increase in mass due to available launches and limitations (like science return) of smallest satellites classes
- Small satellites not always in competition with "Big Birds" anymore – and taken seriously!



Source: Small Satellite Market – Global Forecast to 2022 (2017)

Science Mission Opportunities through Small Satellites

"*Exploration is where microsatellites will hit their home run.*" – M. Griffin, former NASA Administrator

- High Earth Orbit/Lagrangian Point Missions
- Very Low Earth Orbit (VLEO) Missions
- Cis-/Trans-Lunar and Lunar Earth-Moon System Missions
- High-Risk In-Situ Detection
- Short Duration Missions
- Long Duration (e.g. very low thrust) Missions

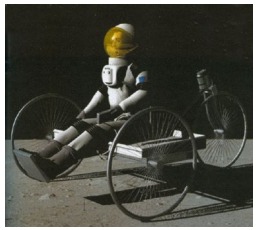
- Networks (Distributed and or Segmented Missions)
- Pico/Nano Satellite Distributor/Carrier Missions
- Continuous, Stored, or Modular Replacements
- Mixed constellations of several small satellite classes

Source: ESA, NAS/RPIF, *Small Satellites: A Revolution in Space Science (USA, 2014)

Some Thoughts on Future Trends (I)

"Don't stop me now" - widen the base at the development cycle: increase the number of pre-phase A studies

➔ increase the idea base (and the out-of-the-box thinking)



"Ask for a ride" – talk to your (beloved ☺) space agency about piggy-back ride-opportunities on own or collaborative launches

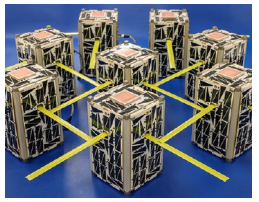
"Shall we dance?" – small satellite historic development showed that international collaboration beyond science participation/payload contribution

➔ widens the component supplier base (for more modular designs)

➔ increases number of missions

➔ creates demand in overall growth in launch opportunities

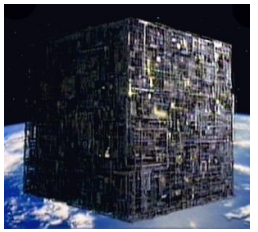
➔ enables lower-cost missions



Source: NASA, K. Ferris (1999), SSTL

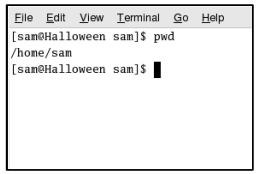
Some Thoughts on Future Trends (II)

"Don't become a fashion victim" – CubeSats are not the only solution to all mission designs. Capability-driven (vs. requirements-driven) mission design can lower cost or even enable missions (in example: illuminators of opportunity) – not limit it!



"Do one thing well" – simplifying your objectives lowers the mission complexity and therefore costs (nothing new but maybe worth the reminder):

➔ small satellites are perfect for that



"Use the power of the… onboard computer" – low-cost high-performance on-board computer power is more and more available and its growth exceeds the increase in larger communication bandwidth – especially when shared in in distributed or segmented small satellite missions:

➔ increase your focus on software than just on hardware: on-board processing!

Source: Paramount, RedHat, Raspberry Pi

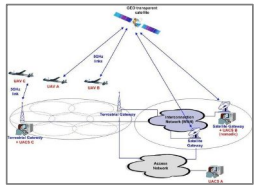
Some Thoughts on Future Trends (III)

"Come Together!" – Strong university small satellite programs as well as strong space agency and industry programs do not exclude each other

➔ bridge the gap and grow in joint collaboration

"Let's mix it up" – combine space elements (including various classes of small satellites) with airborne elements, sea elements and ground elements

➔ systems of systems approach

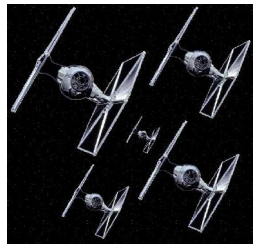


"Outnumber your investigated subject" – take benefit of the advantage of distributed small satellite missions:

➔ for increased fulfillment of objectives (like science return)

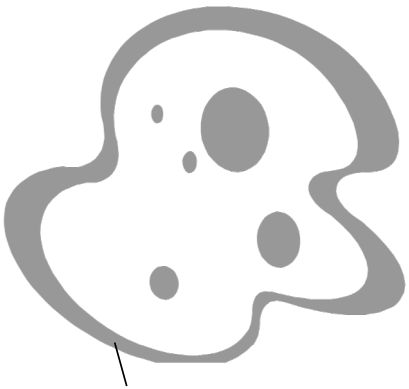
➔ to address risks or due to high risk mission design

➔ due to low cost/expendability (or what René calls the "*TIE-Fighter Effect*")

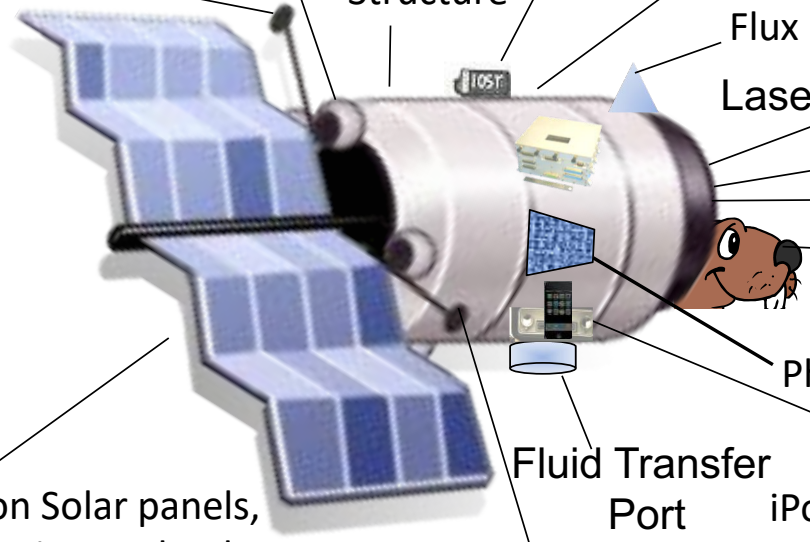


Source: ESA, ISA, LucasArts/Disney

If everyone gets their wish: the microsat of 2020?



Amoeba
(Size Comparison)



Precision Pointing Thrusters
DirecTV
Unobtanium Structure
105 megajoule Capacitor
Cray™ Supercomputer
Flight Computer
Mass: 50 grams
Time travel
Flux Capacitor
Laser rangefinder
Sensor module: Visual/IR/radar/ Sonar/ESP
Marman clamp
Marmot clamp
Phaser bank
Combination Solar panels, Gravity sensing payload, and BBQ grill
Fluid Transfer Port
iPod™/iPhone™/iStarTracker™
Microthrusters
Delta-V 200m/sec
Firing Duration 1.2 million seconds

Cartoon © 2011 by Matt Bille
(Satellite body: Microsoft Office)

Source:s M. Bille (Booz Allen Hamilton)