The case for nanolanders to small bodies

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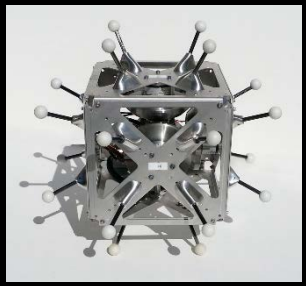
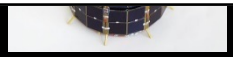




The case for nanolanders to small bodies

Questions?

A small body is not Mars or the Moon:
the surface behavior remains a mystery

A nanolander is the best design we can make today…
… and a nanolander can be a great asset for a mission.

Why don't you use a ***real*** lander?

The future of small bodies exploration

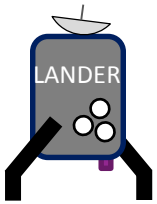
- Several successful missions have investigated small bodies:
  e.g. NEAR-Shoemaker, Hayabusa, Rosetta, …
- New missions will continue these investigations:
  e.g. Hayabusa-2, OSIRIS-Rex, …
- There remains a significant "knowledge gap" on the behavior of asteroid material at the surface.
- There is a crucial need to fill in this gap:
  - for planetary defense
  - for human missions,
  - for in-situ resource utilization,
  - for science!

We need small body landers

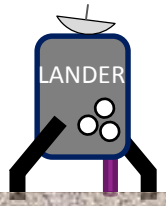
Landing on unpredictable surfaces

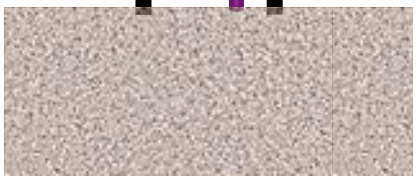
But the same knowledge gaps the lander investigates… could prove fatal!

Unexpected behavior 1



Unexpected behavior 2





Unexpected behavior 3

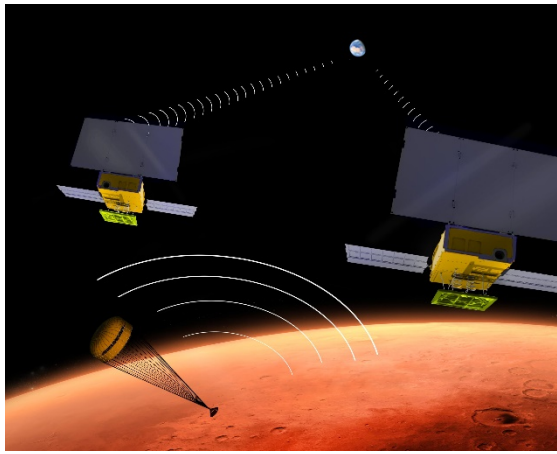
etc.

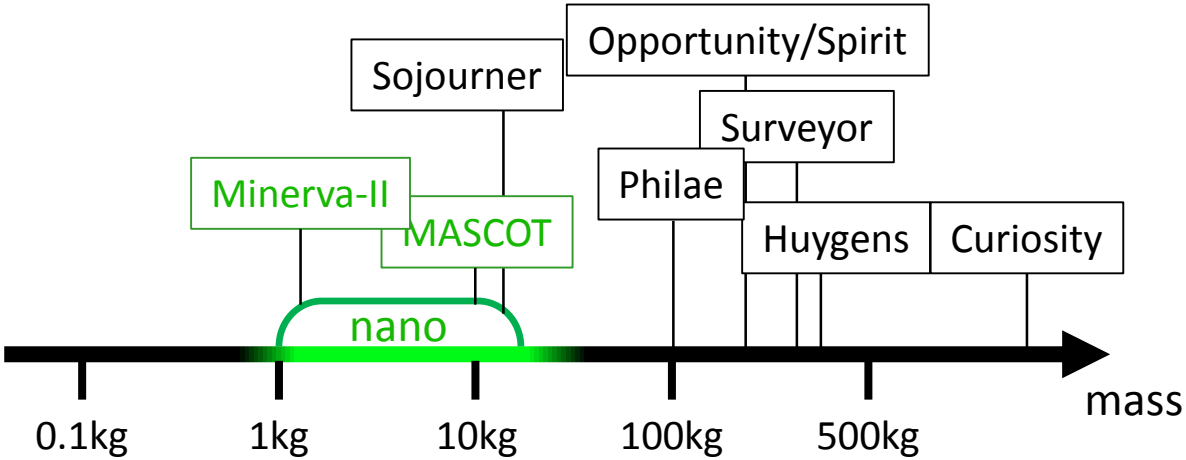
Preparing for most situations is very difficult/costly.

NOT preparing for most situations is very risky.

Nanosats and nanolanders

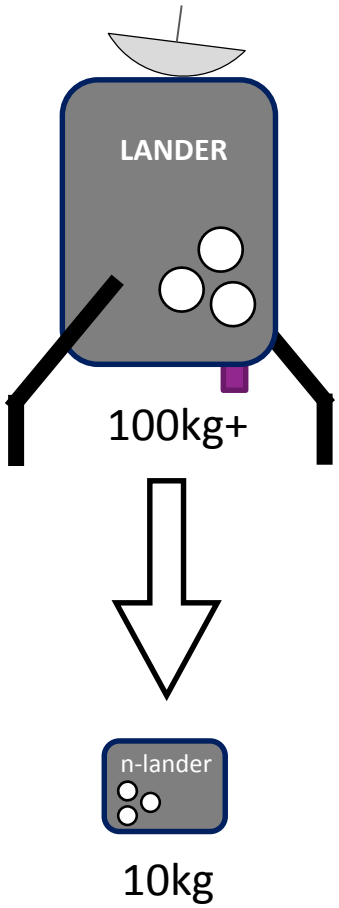
- The CubeSat market has boomed.
  Thousands of launches before 2020 are forecasted.
- Nanosats were academic learning platforms.
- Nanosats are now real science and commercial assets.
- Interplanetary nanosats are becoming a reality
  MarCO (2 x 6U) launches to Mars in 2016 with Insight
- What about “nanolanders”?





A pragmatic solution for in-situ exploration

- Scale down the lander to 1-5 small instruments
  - Low-power, low-mass, low-volume instruments
  - 1 – 25 kg lander total mass
- Remove most of the platform:
  - No/passive landing apparatus
  - No GNC system
  - Rudimentary telecommunications (patch)
  - No/limited redundancy
- Use a mothership/daughtership architecture:
  - Use the mothership's platform to assist the lander
  - Let the lander take all risks (mission and programmatic)

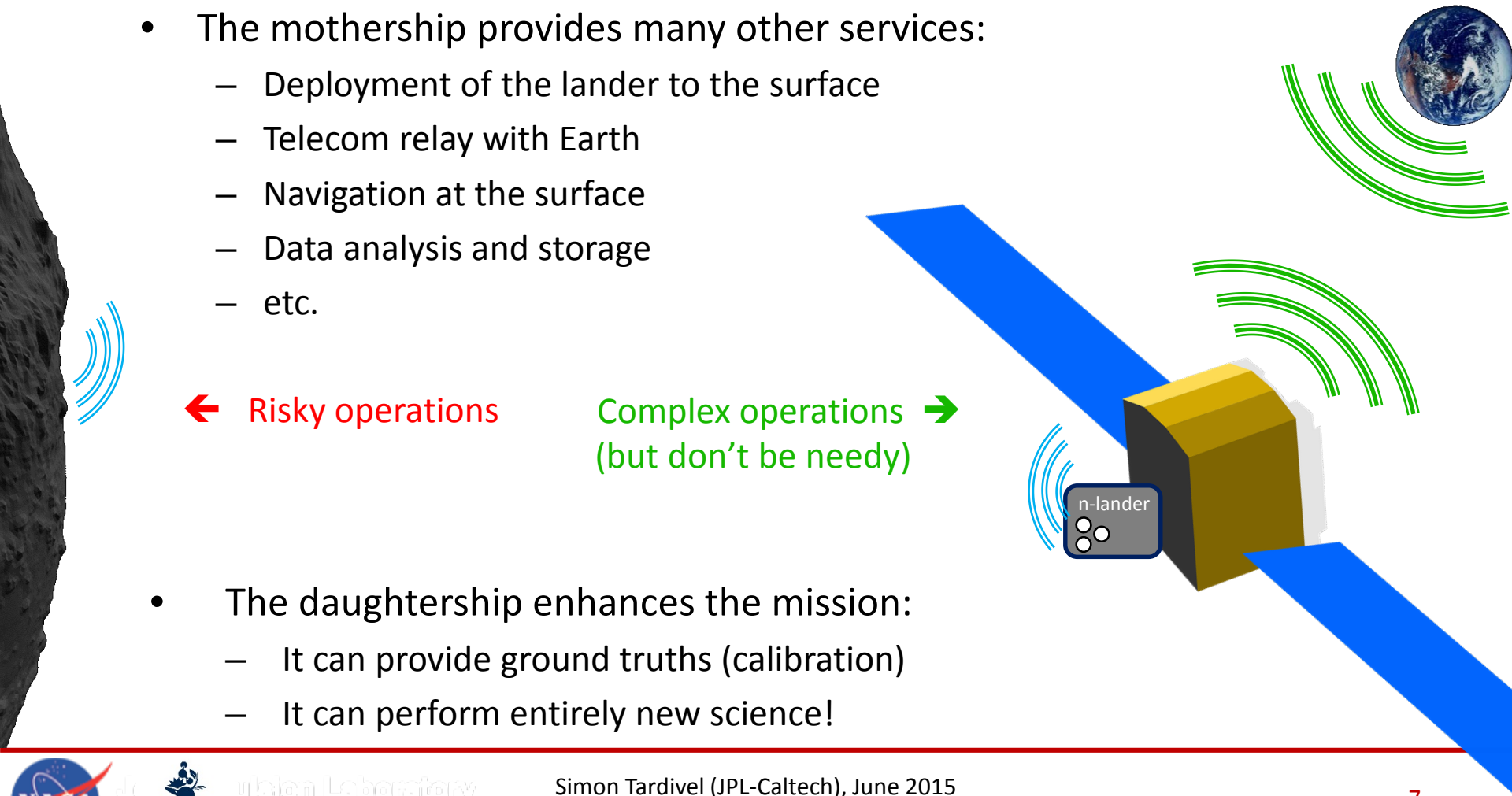


The mothership/daughtership architecture

- The daughtership is brought to the asteroid with the mothership.
- The mothership provides many other services:
  - Deployment of the lander to the surface
  - Telecom relay with Earth
  - Navigation at the surface
  - Data analysis and storage
  - etc.

← Risky operations

Complex operations →
(but don't be needy)



- The daughtership enhances the mission:
  - It can provide ground truths (calibration)
  - It can perform entirely new science!

Nanolanders pros and cons

Good

- Nanolanders are cheap
  - Low mass and low complexity
  - Scaled down version of previously developed instruments
  - Lower requirements for flight qualification
- Nanolanders are payload focused
  - Huge payload/platform ratios
  - Less redundancy, more risk means efficient payload
- Nanolanders are expendables
  - Expendable means bold, bold means high science return!
  - Little programmatic risk

~~Bad~~ Not so good

- The usual "nano" limitations apply
  - Volume, mass, power
  - Lower control on environment (e.g. thermal)
  - "Do-no-harm": nothing hazardous (e.g. pressurized tank)
- Removing the landing platform creates issues
  - Final position of the lander?
  - Final orientation of the lander?
  - Power generation?

➔ Specific solutions exist but depend on the architecture of the lander

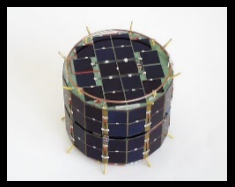
The case for nanolanders at asteroid:

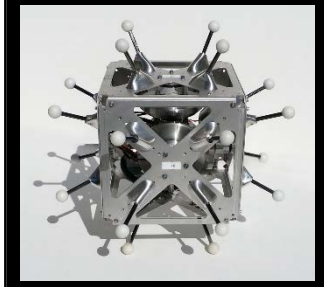
It is feasible.

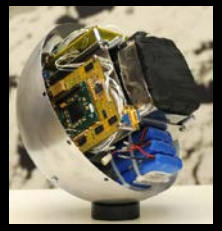
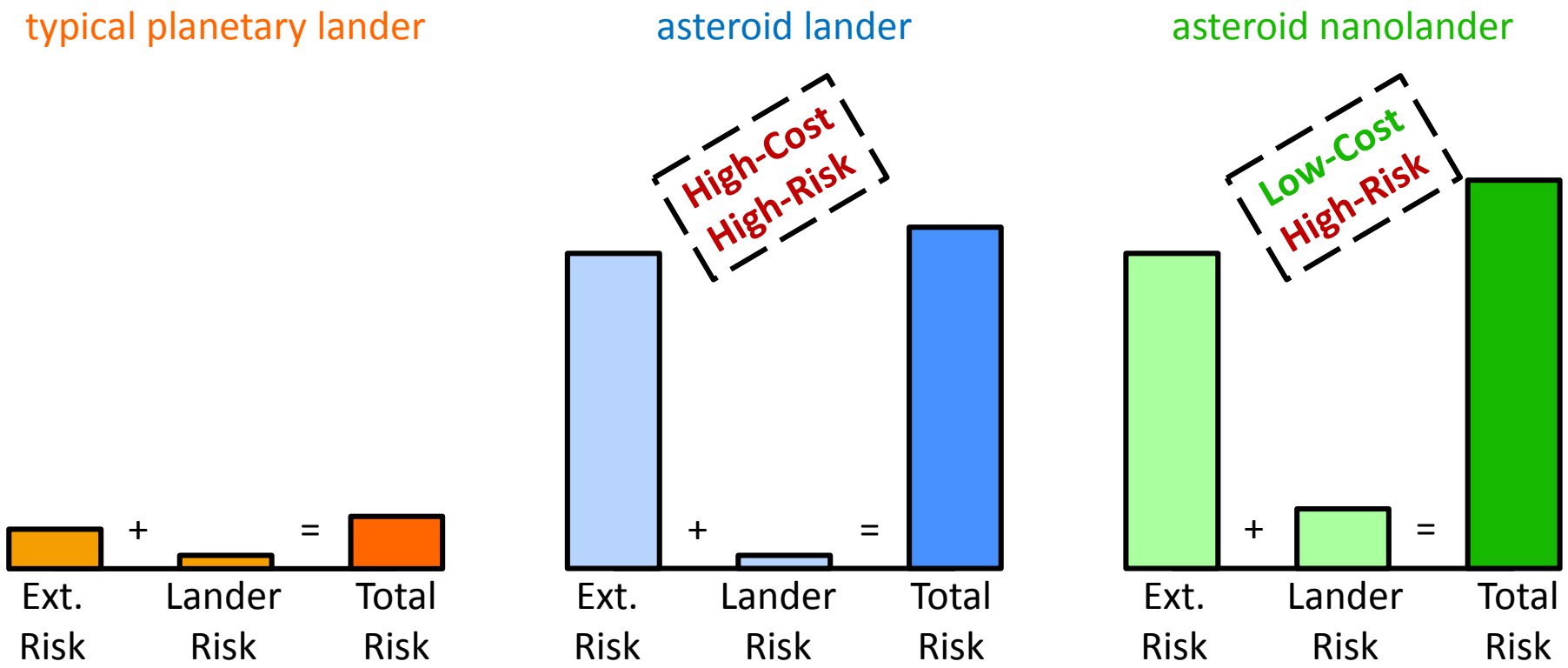
It is great science.

It is efficient.

It is low cost.







The bottom line: a measure of costs and risk