DIAMOND - An Architecture for Persistent Space Platforms

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14 September 2016

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Government sponsorship acknowledged.

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Why Do We Need Persistent Space Platforms?

- To get out of pain:
  - Moving materiel from Earth to space is expensive and time consuming
  - There are limits to how much we can send
  - And it takes a long time to arrange a launch
  - *Once there, we would rather use it forever !*
- Amortize costs over multiple customers
- Send just payloads – not all the equipment
  - Smaller launches
  - Lower cost, more frequent

Why Don't We Have Persistent Platforms?

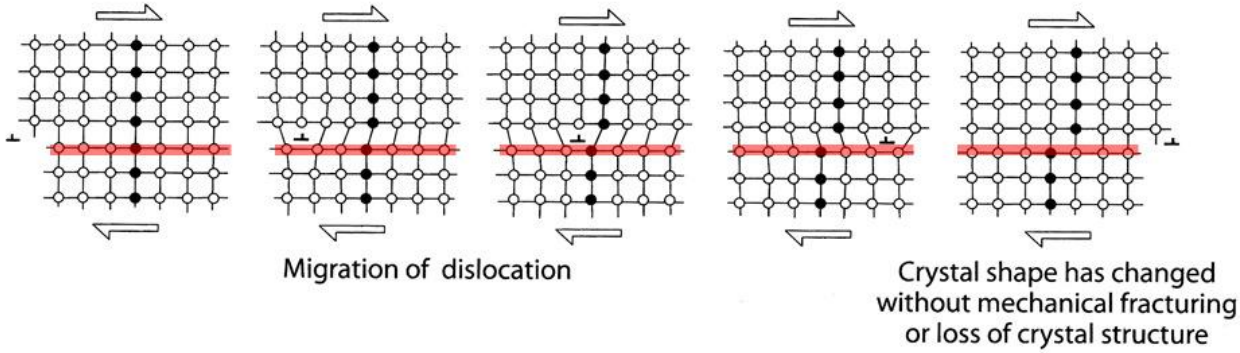
- We try, but life is limited
  - Spacecraft components wear out
  - Spacecraft resources are depleted
  - Technology becomes obsolete
  - Limited life sets limits on returns on investment
- Repair, reuse, recycling in space is very difficult
  - Besides the difficulty of getting there and doing the work…
  - Spacecraft are highly entangled internally

What Do We Need to Do?

- Construct spacecraft in such a way that
  - They could be practically maintained
  - They can be repaired, recycled, and repurposed
  - Over long periods of time
  - Through many cycles of change

- But, How?

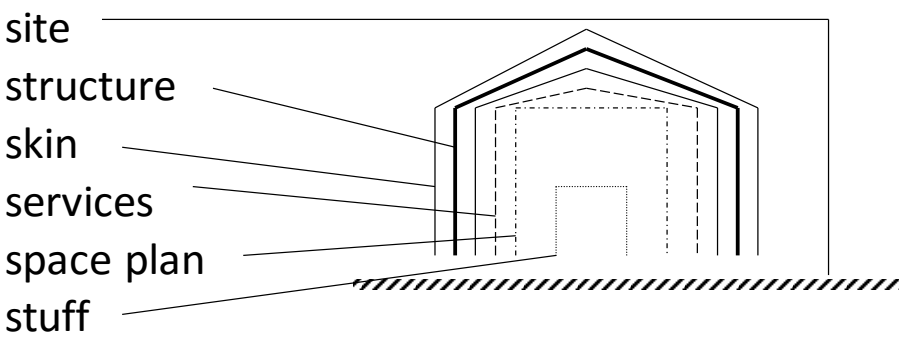
Mechanical Shear/Slip Planes



- In the microscopic world, change occurs at mechanical shearing layers
  - Allow materials to deform plastically without catastrophic damage
  - Useful for a persistent platform
    - Safety
    - Long-term adaptability
  - Enable separation, reattachment, and reconfiguration with limited disruption to most of the structure

Architectural Shearing Layers

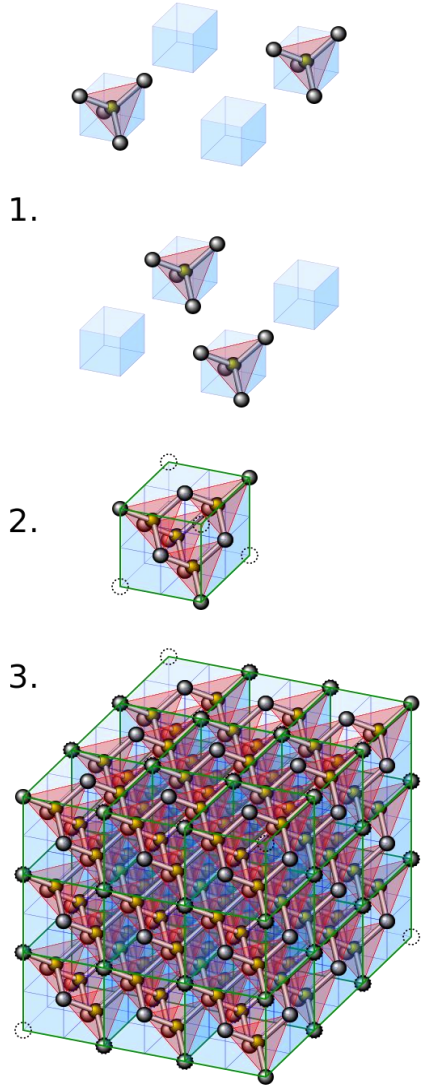
- Generalized architectural shearing layers have also been identified in building architectures and information systems
- Structures which permit easy separation between layers
  are able to persist despite frequent changes



Shearing Layers for a Space Platform

- Structure, arbitrary shapes in a microgravity environment
- Site Attachment, attaching assemblies to the structure
- Power provision
- Thermal Control
- Propulsion and Attitude Control
- Pointing and Vibration Control
- Communication
- Computing

Structural Shearing Layer – Diamond Cubic



- A regular crystal
- Composed of tetrahedral cells to corners of a cube (Figure 1), and empty cells
- Pattern forms larger uniform cubical cells
- Stacked to form arbitrarily large structures
- Natural diamond crystals (and Buckminsterfullerene relatives) are among the strongest materials

Image source: https://en.wikipedia.org/wiki/File: Visualisation_diamond_cubic.svg.
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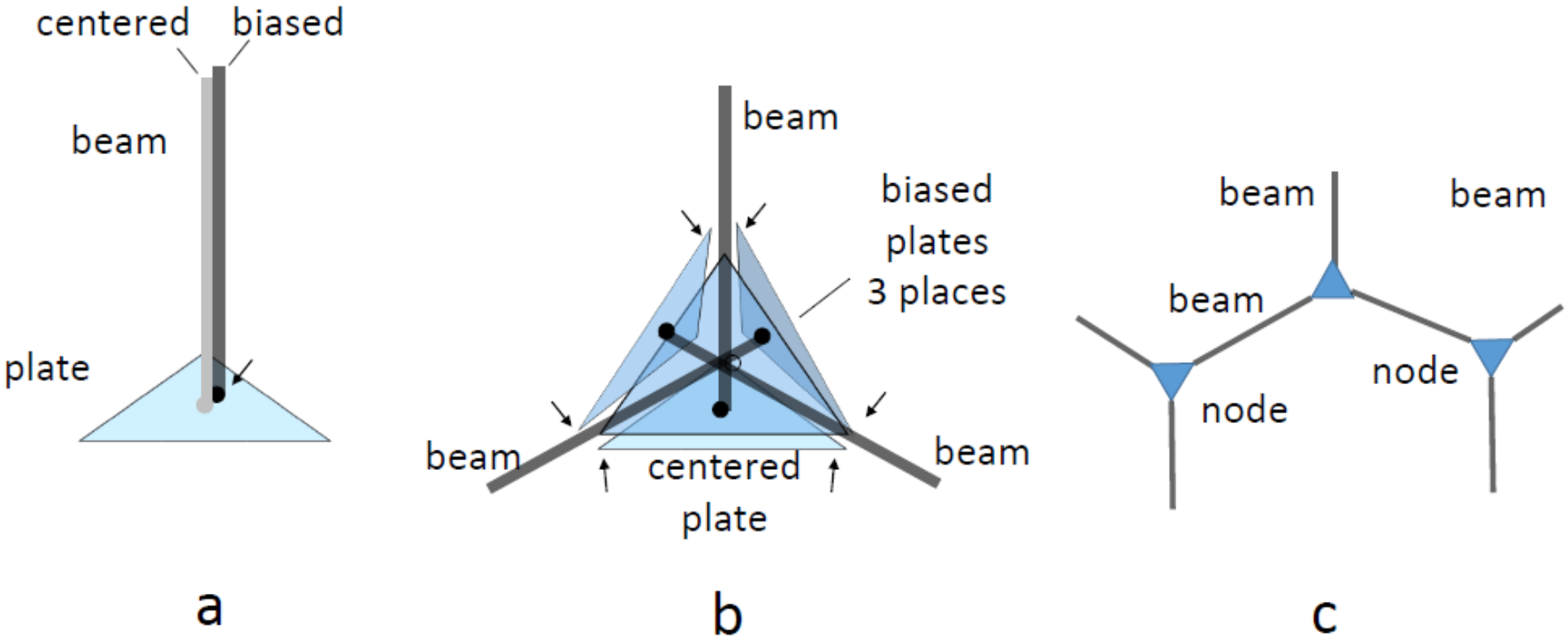
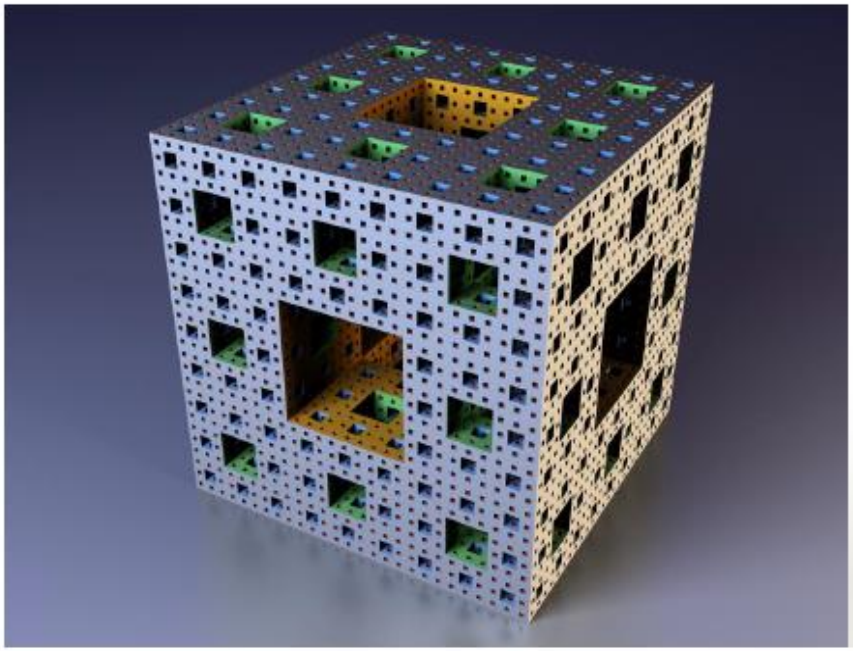
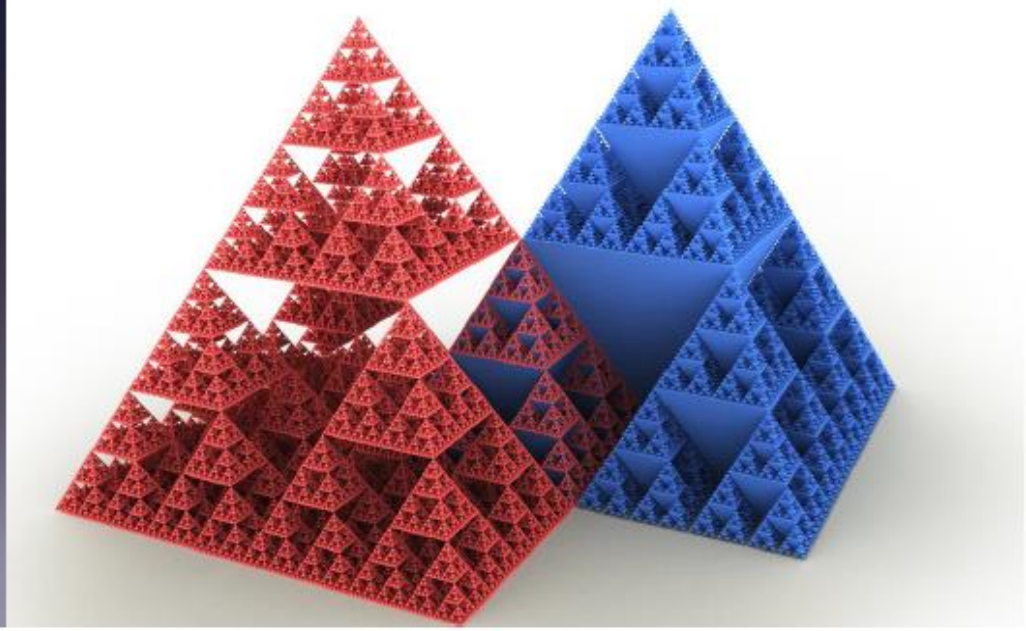
Initial Construction – One Possible Approach



Extension of the Structural Shearing Layer – Fractal Sponges



Menger sponge



Sierpinski pyramid and its inverse

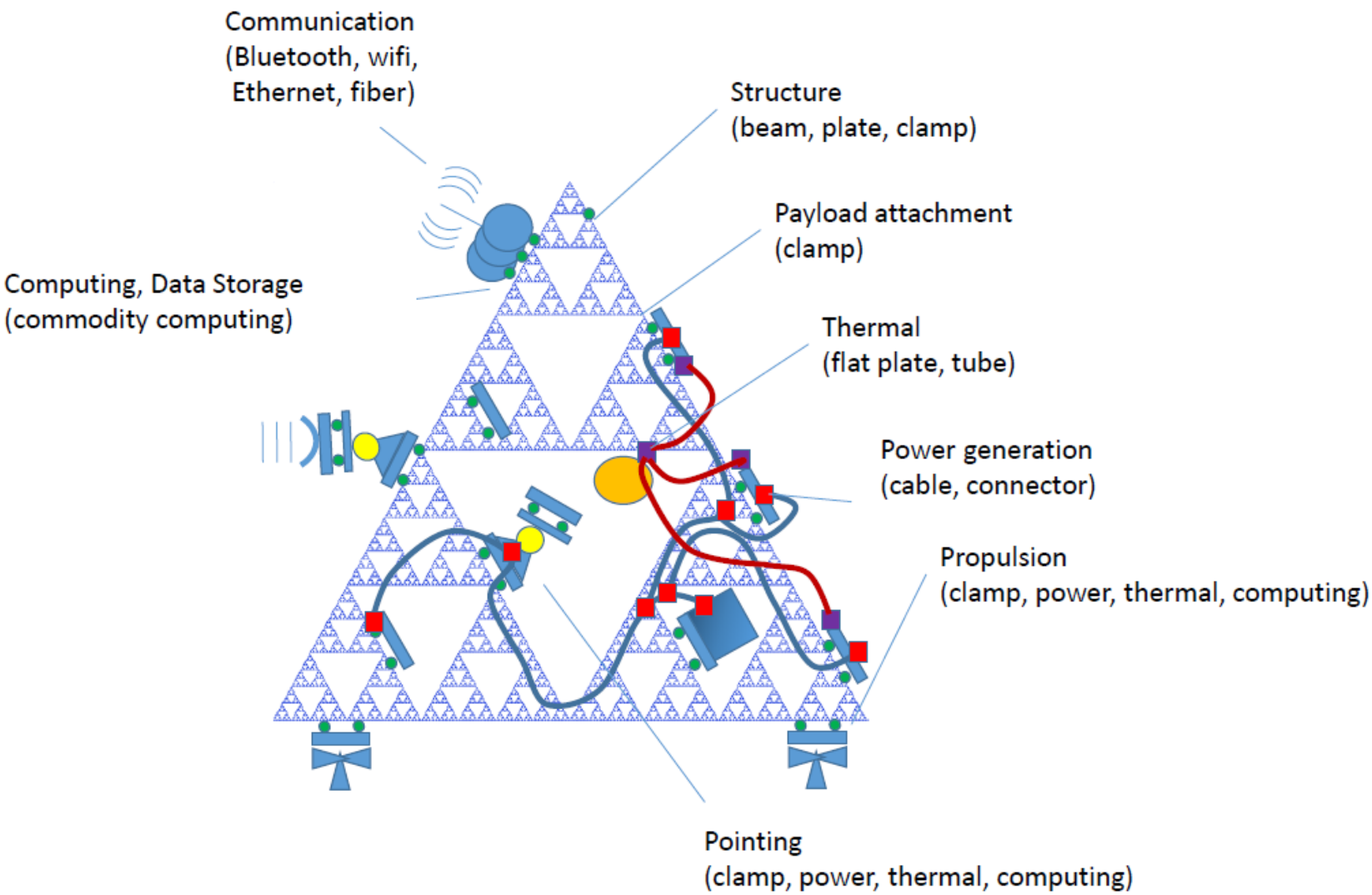
Image source: https://en.wikipedia.org/wiki/Menger_sponge
https://en.wikipedia.org/wiki/Sierpinski_triangle . Used under a Creative Commons license.

Site Attachment Shearing Layer

- Arrays of beam locations in the diamond cubic
- Matching arrays of clamps
- Could be a hinged split-ring bracelet clamp, similar to a common scaffolding clamp

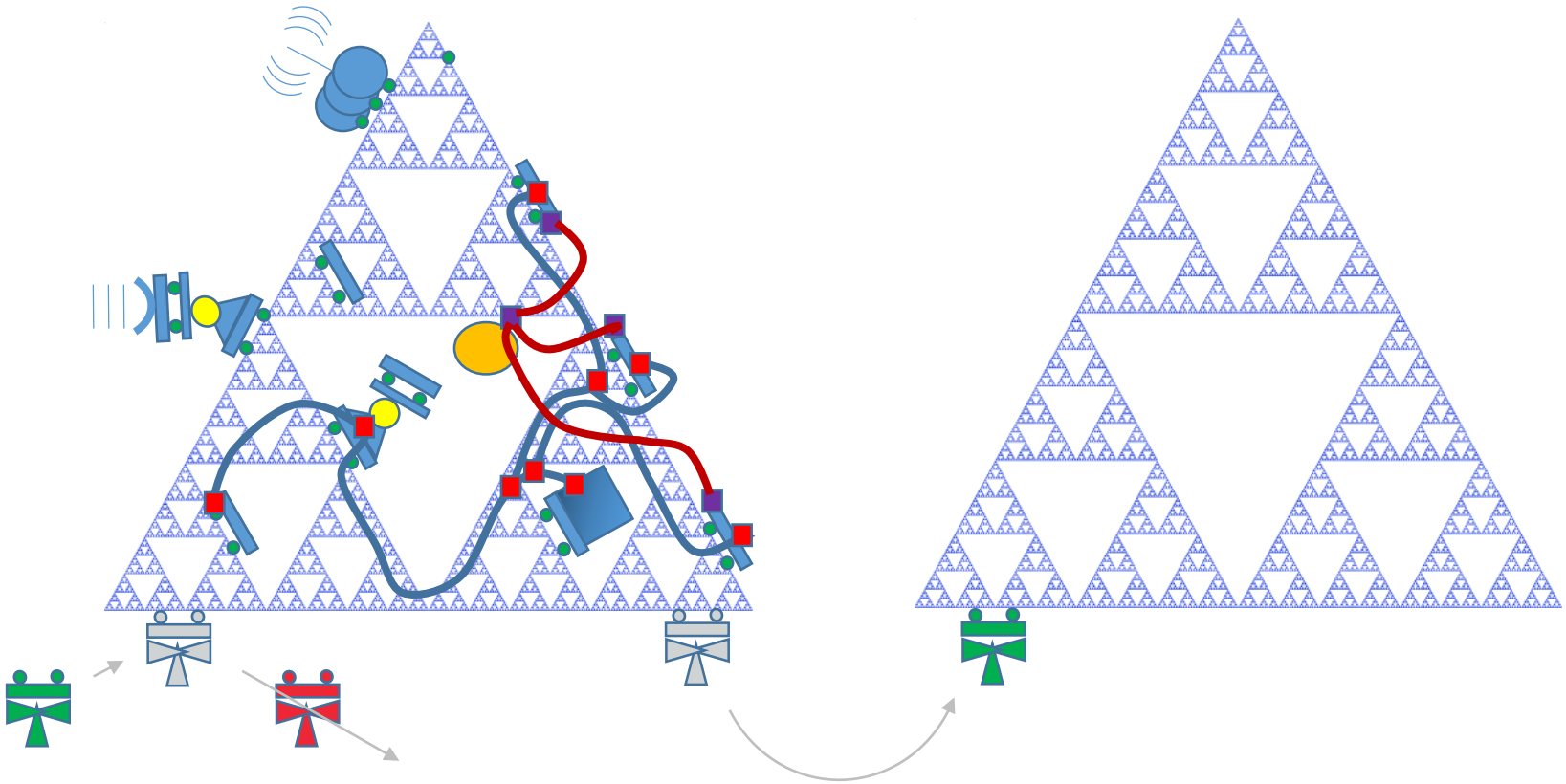
Image source: https://en.wikipedia.org/wiki/File:Coupler_1.jpg . Used under a Creative Commons license.

More Shearing Layers – Services as a Payload



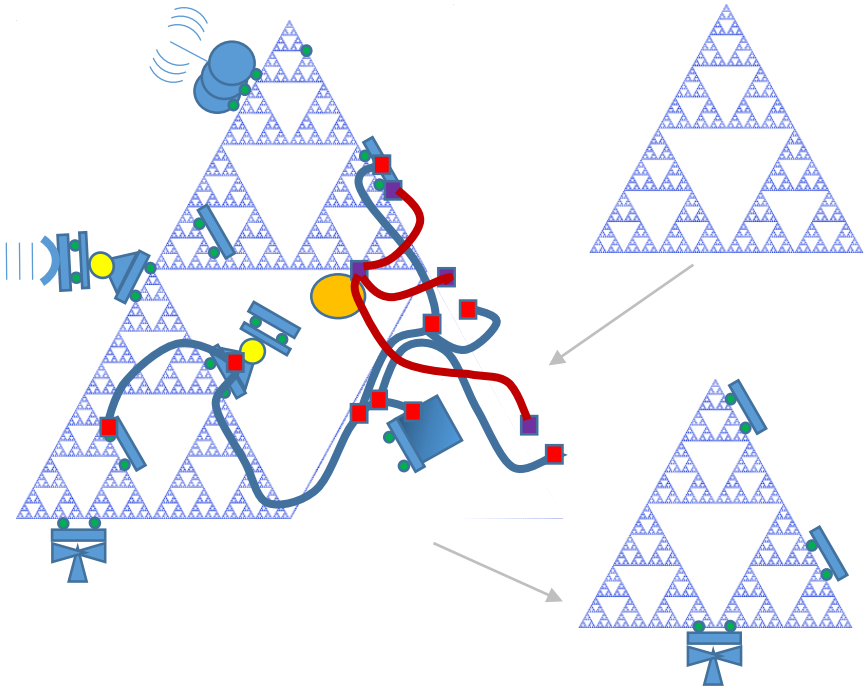
Recycling and Reuse

- Old assemblies can be detached then replaced, scavenged, or moved



Platform Factories

- Reuse fragments of a platform by disconnecting at convenient locations
- Form smaller platforms separately, then join together



Ecosystem Around a Space Platform

- Independent Service Provision
  - Service separation at architectural shearing layers
  - Third-party utility services providers operate as they do on Earth
  - Service technology can change independent of customers
- Occupancy
  - Shearing layers permit temporary occupancy: rent, lease, or buy
  - When a mission ends, owner may end the arrangement, or sell their real estate
- Ownership
  - Sell and buy real estate on the platform
    - Attachment sites
    - Structure itself
    - Payloads

Ecosystem Around a Space Platform (Cont'd)

- Real Estate Governance Model
  - Reapply centuries of legal precedent
  - Successful, terrestrial, real-estate model
  - Tenants to have a right to "peaceful enjoyment"
- Demand-driven Pricing
  - Some will prefer surface real estate
  - Some will prefer lower interior attachment site if price is lower
  - Market determines best prices

The DIAMOND Architecture Shearing Layers

Architectural Shearing Layer	Typical Interface	Low rate-of-change Platform Infrastructure	High rate-of-change Tenant payloads
Structure	Nodes and Beams	Persistent Platform	Construction projects, spawning/docking of other platforms
Site Attachment	Quick-Disconnect Clamp	Service-providing assemblies	Tenant assemblies
Power provision	Space-qualified Power Plugs	Power Cables, Power meters, generation facilities	Service entrances to tenant payloads
Thermal Control	Thermal contact plate, cylindrical clamp	Heat pipes, solid heat conductors	Thermal control services payloads
Propulsion and Attitude Control	Site Attachment, power, thermal, communication, computing	Platform maneuvering assemblies	Payload maneuvering assemblies
Pointing and Vibration Control	Site attachment, power, thermal, communication, computing	Observatory assemblies	Tenant payload pointing and isolation assemblies
Communication	Bluetooth, Wi-Fi, Ethernet, Fiber, Optical and RF off-platform	Local Area Network on Ethernet and optical fiber, Wi-Fi Access points	Off-platform communications payloads
Computing and Data Storage	Cloud computing service interface	Servers, data center	Tenant payload computing services

Advantages of the DIAMOND Architecture

- Provides separable layers, free of excessive entanglement
- Enables layers to change at different timescales without disrupting other layers
- Payloads, platforms, services can be renewed continuously; structures and services can be expanded to sizes larger than can be launched
- Payloads can be sent without a self-supporting spacecraft
- Reuses materiel previously sent to space
- Investment is easily adjustable as new customers emerge (build a little, sell a little)
- Nothing excessively challenging about any of the layers

Acknowledgments

The work contributed by the Jet Propulsion Laboratory, California Institute of Technology, was performed under a contract with the National Aeronautics and Space Administration.

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