



Designing Scalable Testbeds for Distributed Spacecraft Autonomy

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Project Overview & Technical Focus Areas

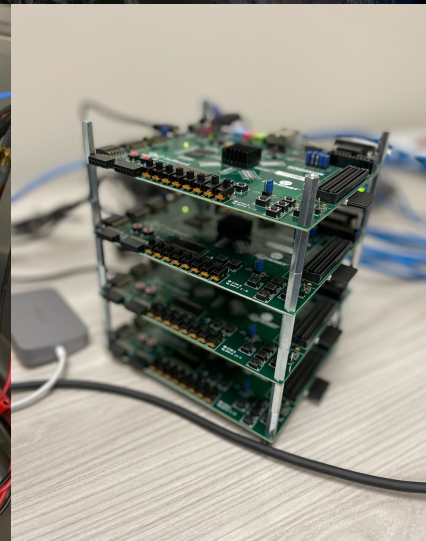
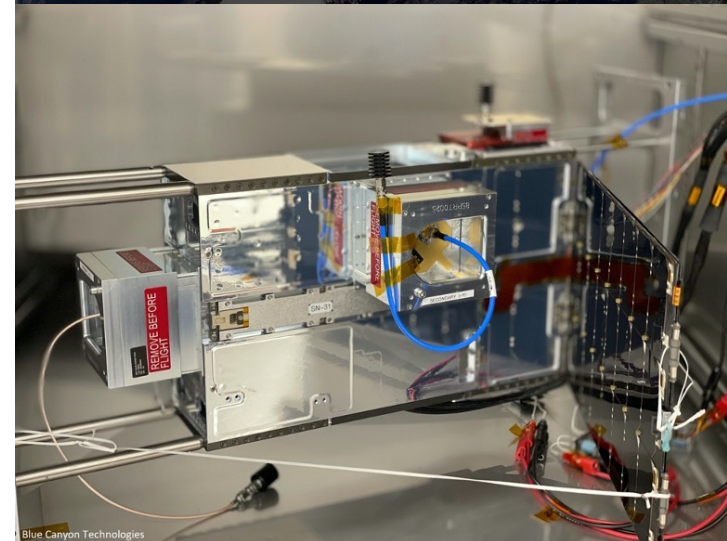
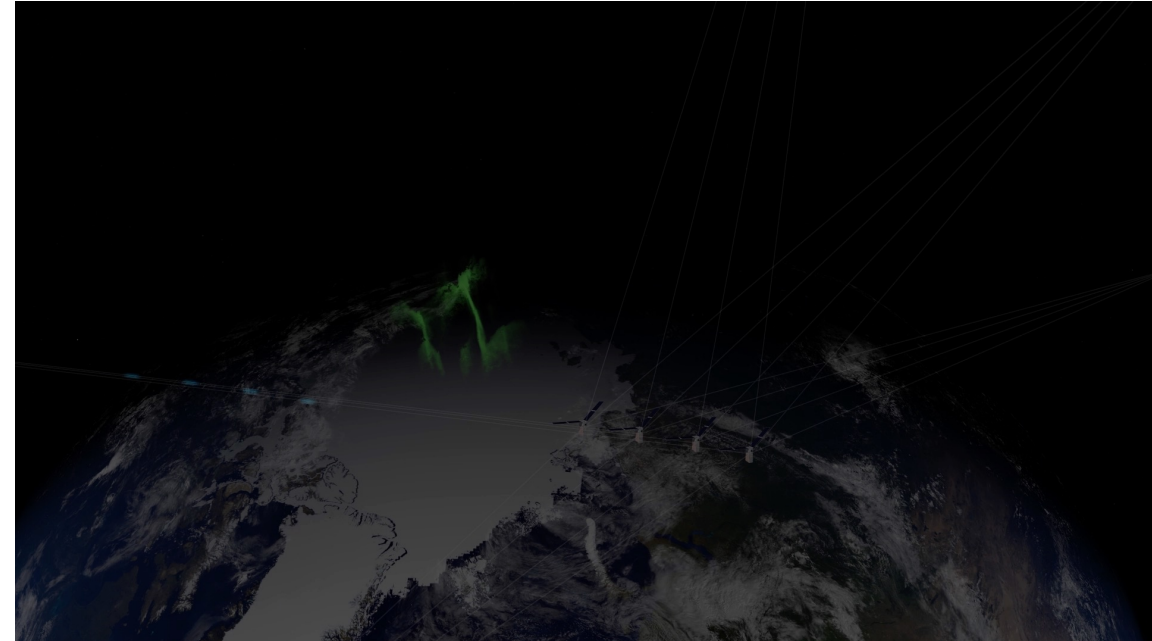
Distributed Resource and Task Management: demonstrate Executive and Scheduler software modules which are extended from existing single-spacecraft approaches to coordinate large number of independent distributed assets

Reactive Operations: develop algorithms to refine model and optimize collection strategy; leverage algorithms appropriate for dynamic sensing and other real-time adjustments to operations

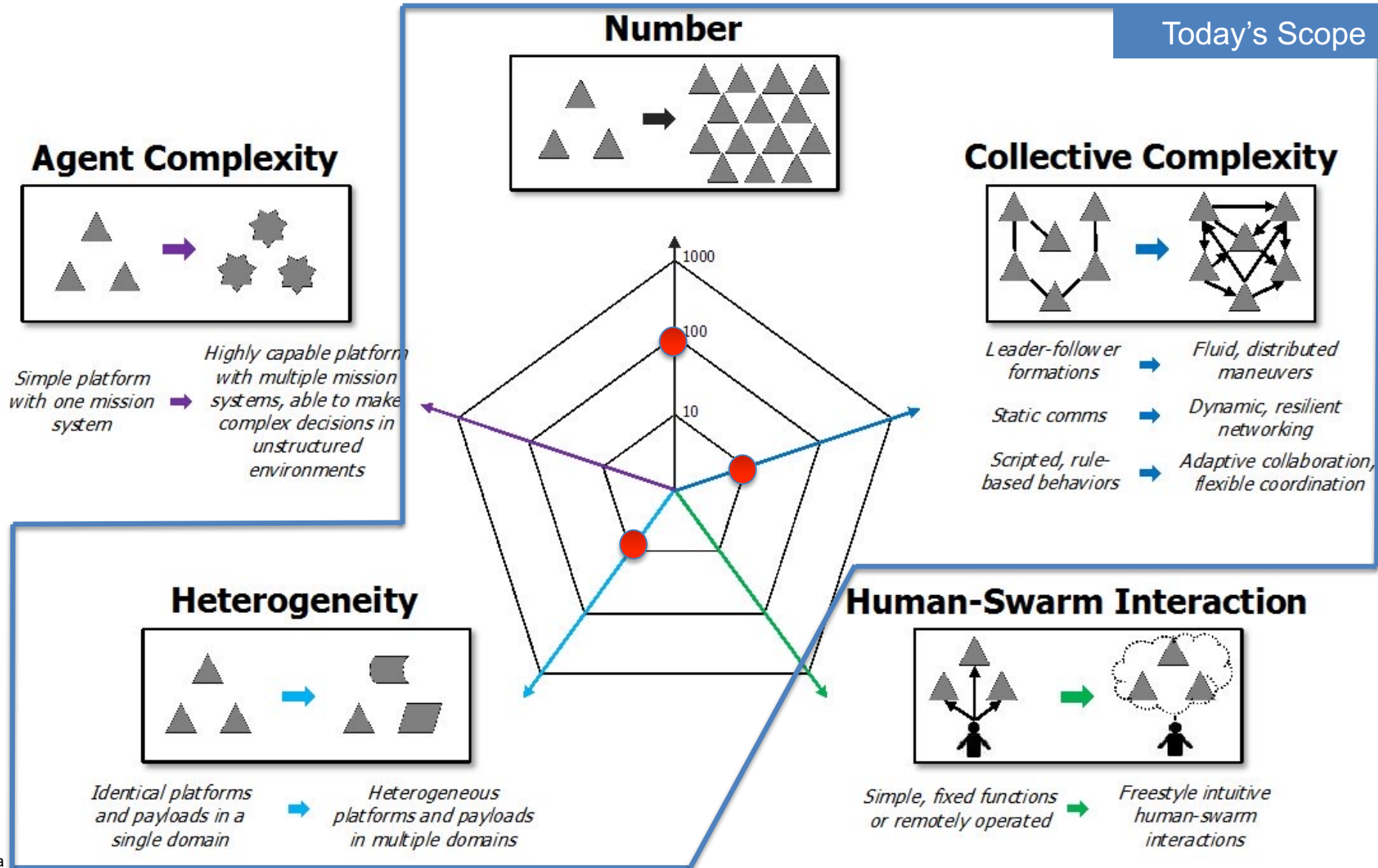
System Modeling and Simulation: capture desired mission capabilities as models of system functions and then iteratively refine these models for scalability

Human-Swarm Interaction: ground control software that enables the ability to command and interact with the spacecraft as a collective

Ad hoc Network Communications: communication infrastructure that is scalable, robust, and automatically self-configuring

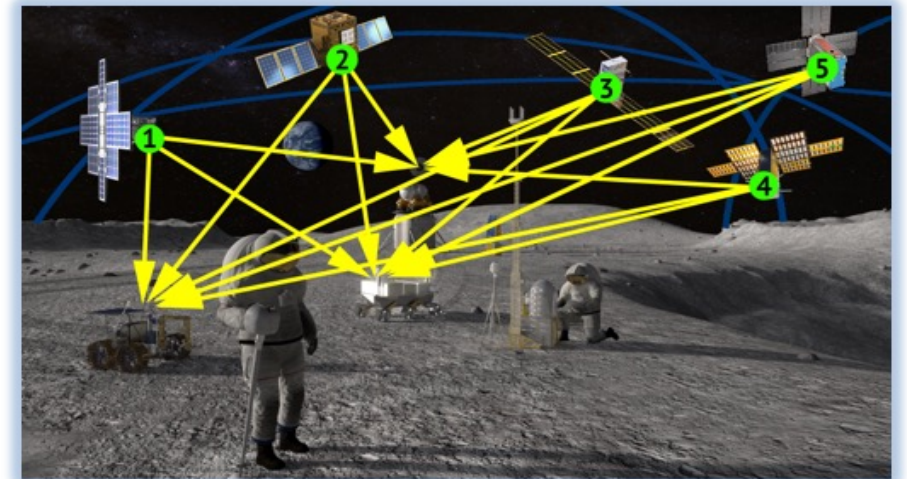
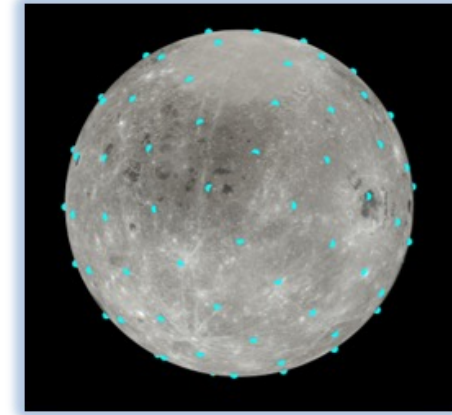


Today's Topic: Scalability is Challenging



Lunar Position, Navigation, and Timing (LPNT) demo

- LPNT builds & extends existing DSA work
 - Larger than DSA+Starling
 - Service driven
 - 100 Nodes for localization
- (toy problem) Assumes ubiquitous deployment of lunar satellites
- Algorithms for LPNT tested with increasing realism
- LPNT desires "near-future" processors for testbed



Hardware Selection

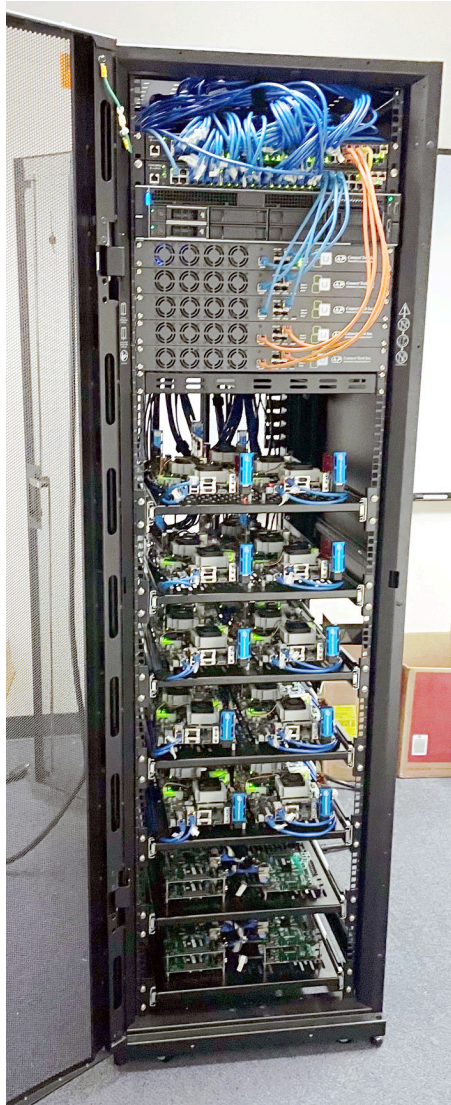


Table 1. Processing unit representation in DISSTRACK

Quantity	Device Model	CPU	GPU	FPGA
60	Nvidia Jetson Xavier AGX	✓	✓	
25	Unibap e2160 Qseven	✓	✓	✓
15	Avnet Zedboard	✓		✓

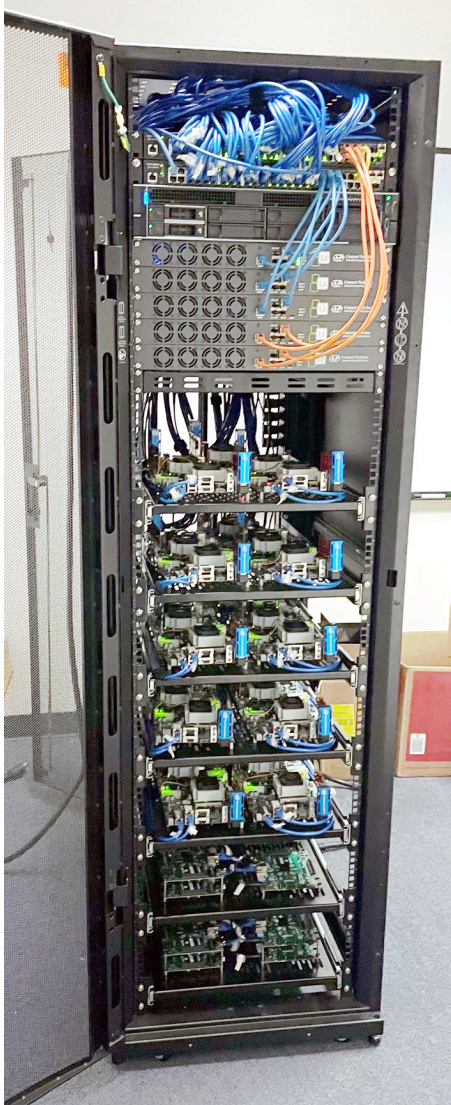
Full paper:



Table 2. Processor-in-the-loop architecture specification details

Component	Board	Architecture	Processing Cores	Memory	Max Freq.
CPU	Nvidia Jetson Xavier AGX	ARM-v8.2 (64-bit)	8 Logical	32 GB	2.3 GHz
	Unibap e2160 Qseven	x86 (64-bit)	4 Logical	2 GB	1.2 GHz
	Avnet Zedboard	ARM-v7 (32-bit)	2 Logical	512 MB	667 MHz
GPU	Nvidia Jetson Xavier AGX	Nvidia Volta	512 CUDA	shared w/ CPU	1.37 GHz
	Unibap e2160 Qseven	AMD Radeon R3E	2 CU	shared w/ CPU	350 MHz
FPGA	Unibap e2160 Qseven	Microsemi SmartFusion2	57k Logic Elements	512 MB	
	Avnet Zedboard	Xilinx Artix-7	85k Logic Cells		

LPNT Shared State Demo



Node 8

Node 32

```
Work (zsh) x1
x spacecloud@spacecloud-ode-00-f0: ~ (ssh)
root@spacecloud-ode-00-f0
OS: Ubuntu 20.04 focal
Kernel: x86_64 Linux 5.15.15-051515-generic
Uptime: 16m
Packages: 2438
Shell: sh
Disk: 22G / 81G (29%)
CPU: AMD GX-412HC SOC with Radeon R3E Graphics @ 4x 1.2GHz
GPU: Advanced Micro Devices, Inc. [AMD/ATI] Mullins [Radeon R3E Graphics] (rev 01)
Device abba:babe
RAM: 719MiB / 1707MiB
EDAC driver/chip: F16h_M30h (amd64_edac.c; EDAC,ErrorScrub,BackgroundScrub)
RAM location and identification: mc#0csrow#0channel#0
Memory size covered by EDAC/ECC: 2048 MB RAM
RAM DIMM EDAC mode: SECDED
Background memory scrubbing rate: 97650 Bytes/second
- Full memory scrub takes 21991 seconds, 366 minutes, 6 hours at this rate
Seconds since EDAC/ECC reset: 969 seconds
Uncorrectable error count is 0 on memory controller
Correctable error count is 0 on memory controller
PCI parity checking enabled (1 = true): 1
Last login: Fri Sep 2 23:12:07 2022 from 192.168.2.1
spacecloud@spacecloud-ode-00-f0:~$ _

x spacecloud@spacecloud-ode-00-f0: ~ (ssh)
root@spacecloud-ode-00-f0
OS: Ubuntu 20.04 focal
Kernel: x86_64 Linux 5.15.15-051515-generic
Uptime: 16m
Packages: 2428
Shell: sh
Disk: 22G / 81G (28%)
CPU: AMD GX-412HC SOC with Radeon R3E Graphics @ 4x 1.2GHz
GPU: Advanced Micro Devices, Inc. [AMD/ATI] Mullins [Radeon R3E Graphics] (rev 01)
RAM: 707MiB / 1707MiB
EDAC driver/chip: F16h_M30h (amd64_edac.c; EDAC,ErrorScrub,BackgroundScrub)
RAM location and identification: mc#0csrow#0channel#0
Memory size covered by EDAC/ECC: 2048 MB RAM
RAM DIMM EDAC mode: SECDED
Background memory scrubbing rate: 97650 Bytes/second
- Full memory scrub takes 21991 seconds, 366 minutes, 6 hours at this rate
Seconds since EDAC/ECC reset: 980 seconds
Uncorrectable error count is 0 on memory controller
Correctable error count is 0 on memory controller
PCI parity checking enabled (1 = true): 1
Last login: Fri Sep 2 23:12:15 2022 from 192.168.2.1
spacecloud@spacecloud-ode-00-f0:~$ _
```

```
x ./demo.sh (ssh)
- unibap-10
- unibap-11
- unibap-12
- unibap-13
- unibap-14
- unibap-16
- unibap-17
- unibap-18
- unibap-19
- unibap-20
- unibap-21
- unibap-22
- unibap-23
- unibap-24
- unibap-25
- unibap-26
- unibap-27
- unibap-28
- unibap-29
- unibap-30
- unibap-31
- unibap-32
- unibap-8
DEBUG: starting run...
DEBUG: salt start command is: salt -C 'unibap*' cmd.run 'screen -S "lpnt-test" -L -
d -m bash; screen -r "lpnt-test" -X stuff "echo "=====RUN===== "\ndate
+%\ncd /root/cpu\nchr -f 99 /core-cpu\n"'
INFO: Starting execution on minions...
unibap-8:
unibap-13:
unibap-14:
unibap-10:
unibap-12:
unibap-11:
unibap-18:
unibap-30:
unibap-17:
unibap-29:
unibap-22:
unibap-28:
unibap-21:
unibap-25:
unibap-31:
unibap-25:
unibap-19:
unibap-20:
unibap-16:
unibap-24:
unibap-27:
unibap-23:
... DONE!
Ready to start command sequence?
Press any key to continue or Ctrl+C to exit...
```

All of the available nodes