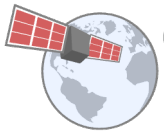
CISPA
HELMHOLTZ CENTER FOR INFORMATION SECURITY



SPEL
Space and Planetary Exploration Laboratory

HoneySat: A Network-based Satellite Honeypot Framework

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**Equal Contribution*

Ulysse Planta

Deception with Honeypots

- **Lures attackers** into controlled, instrumented decoys
- **High-interaction “mission realism”:** Real ground tools + realistic interfaces
- Detecting presence (and methods) of Attackers
- Honeypots often mimic key behaviors, not the full real system
- **We need a realistic decoy that doesn’t require mission-specific internals and doesn’t reveal how the real mission works**

Motivation

Viasat

APT Targeting

Multiple Companies

STARLINK

GPS

Viasat KA-SAT

Feb. 2022

TIDRONE

Sep. 2024

Starlink Infrastructure Breach Attempts

Early 2025

GPS Spoofing

Aug. 2025

Motivation

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- **Permanent damage to onboard systems**
- **How are these incidents connected?**

Objectives

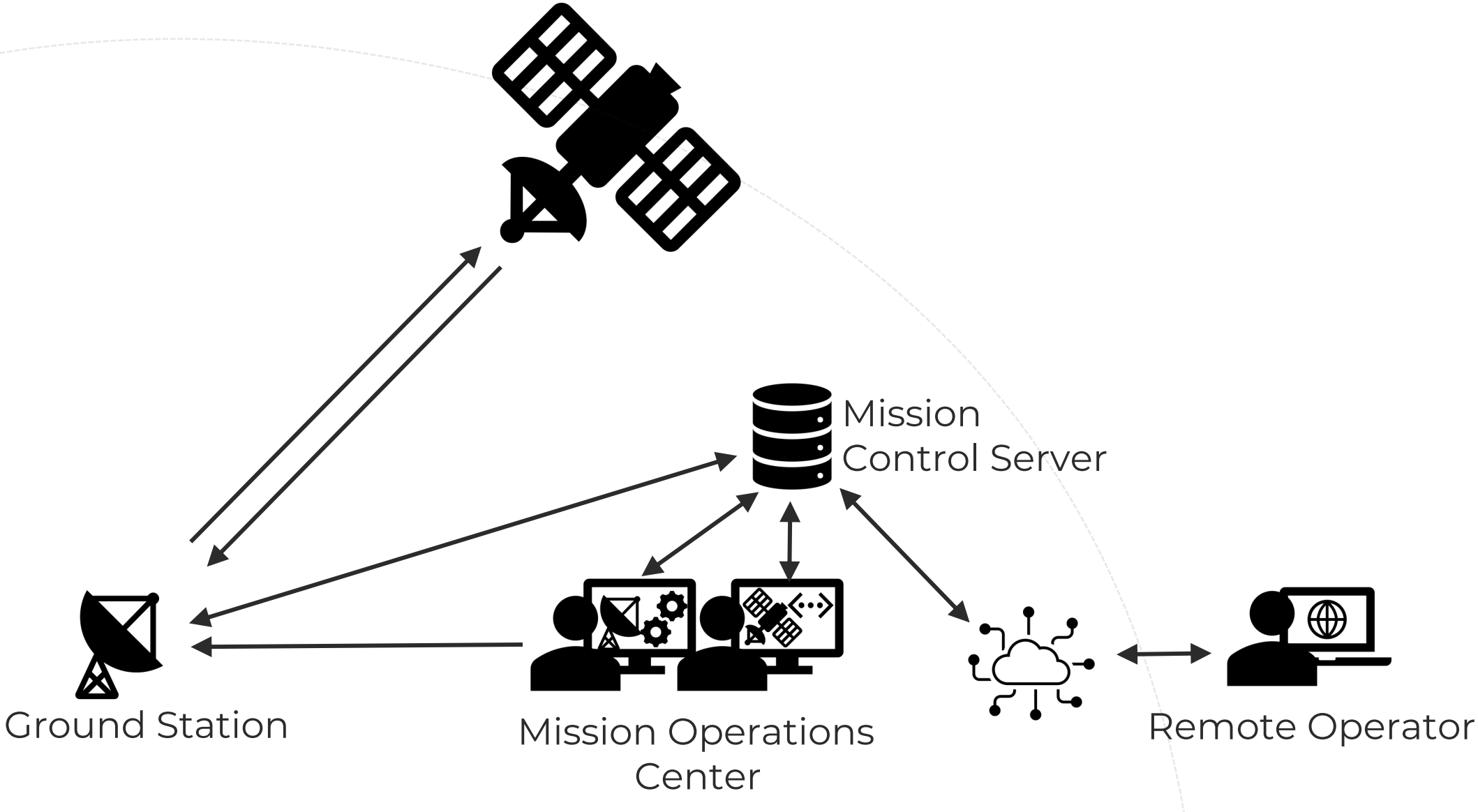
Design Objectives of a Satellite Honeypot

I. Capture Rich interaction Data

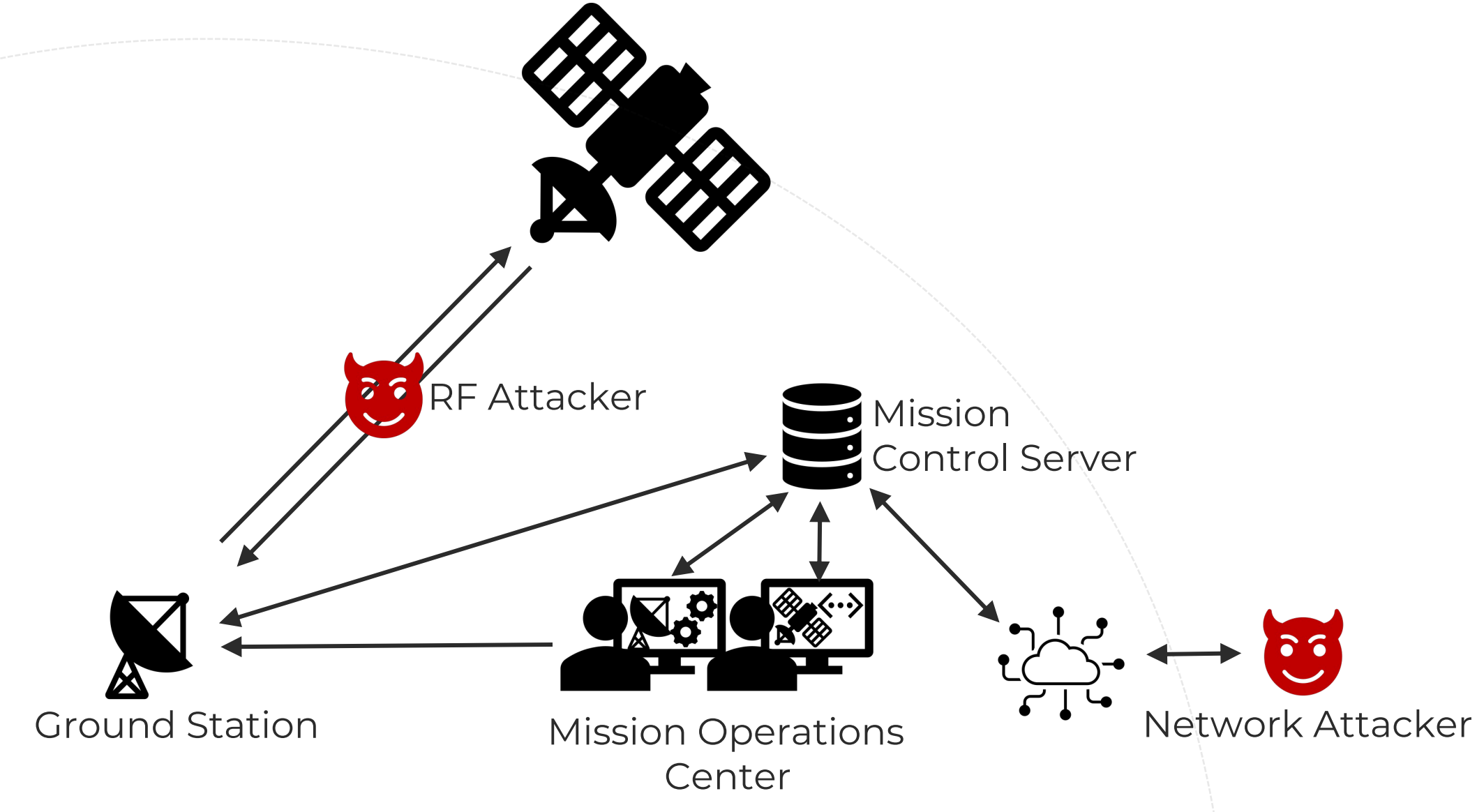
II. Deception

III. Extensibility and Customizability

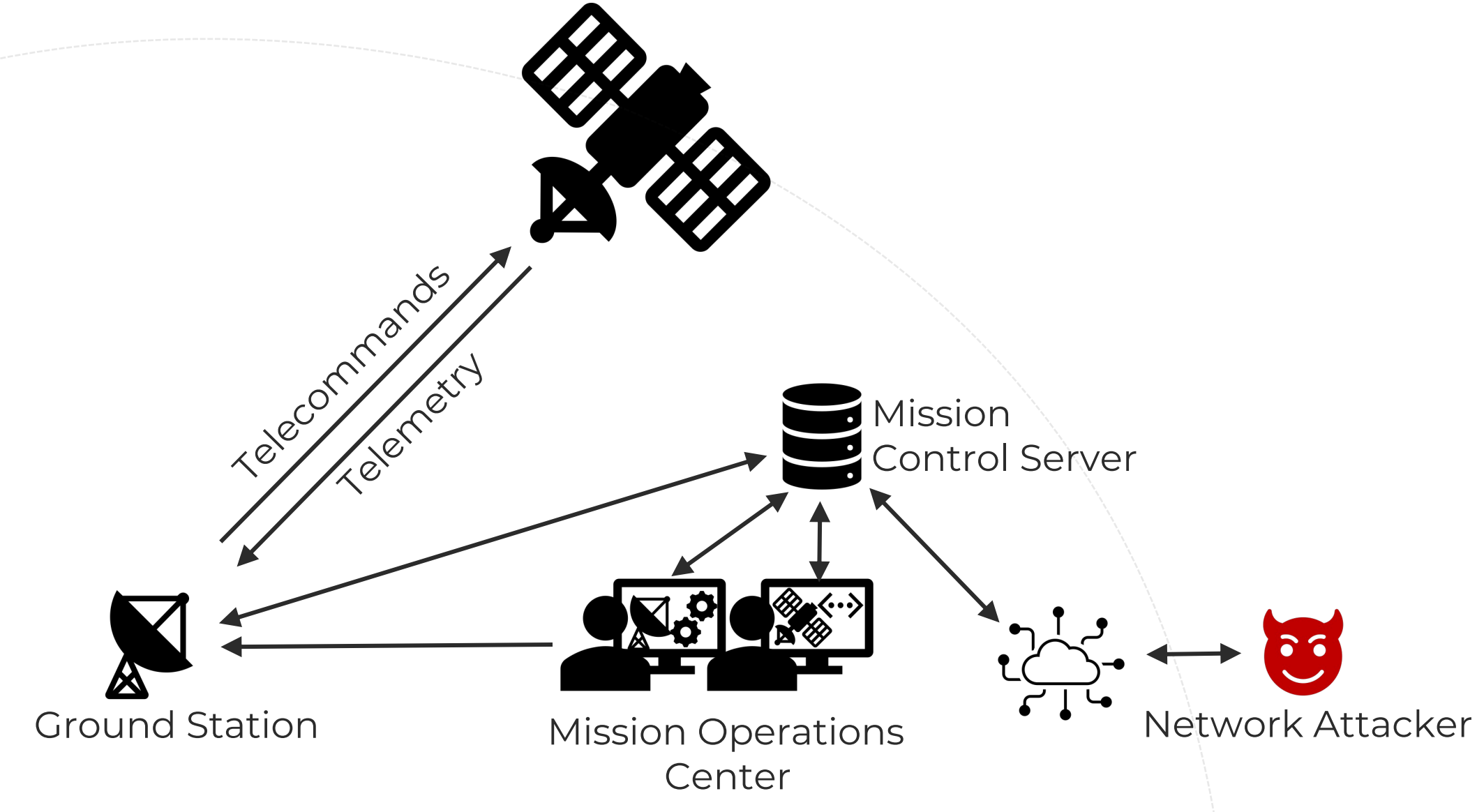
Overview


Mission
Control Server
Ground Station
Mission Operations
Center
Remote Operator

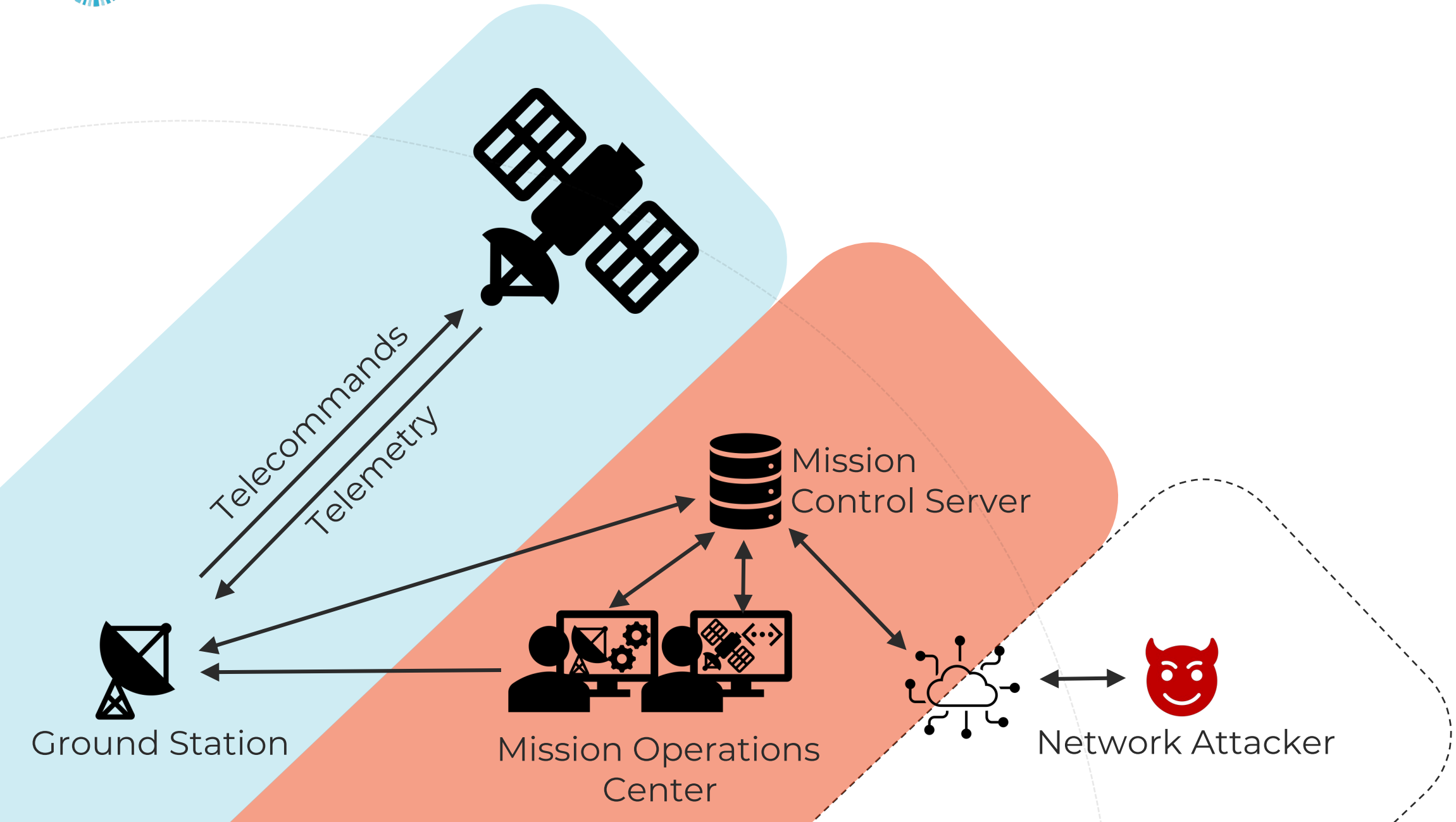
Attacker Model



HoneySat


Telecommands
Telemetry
Mission
Control Server
Ground Station
Mission Operations
Center
Network Attacker

HoneySat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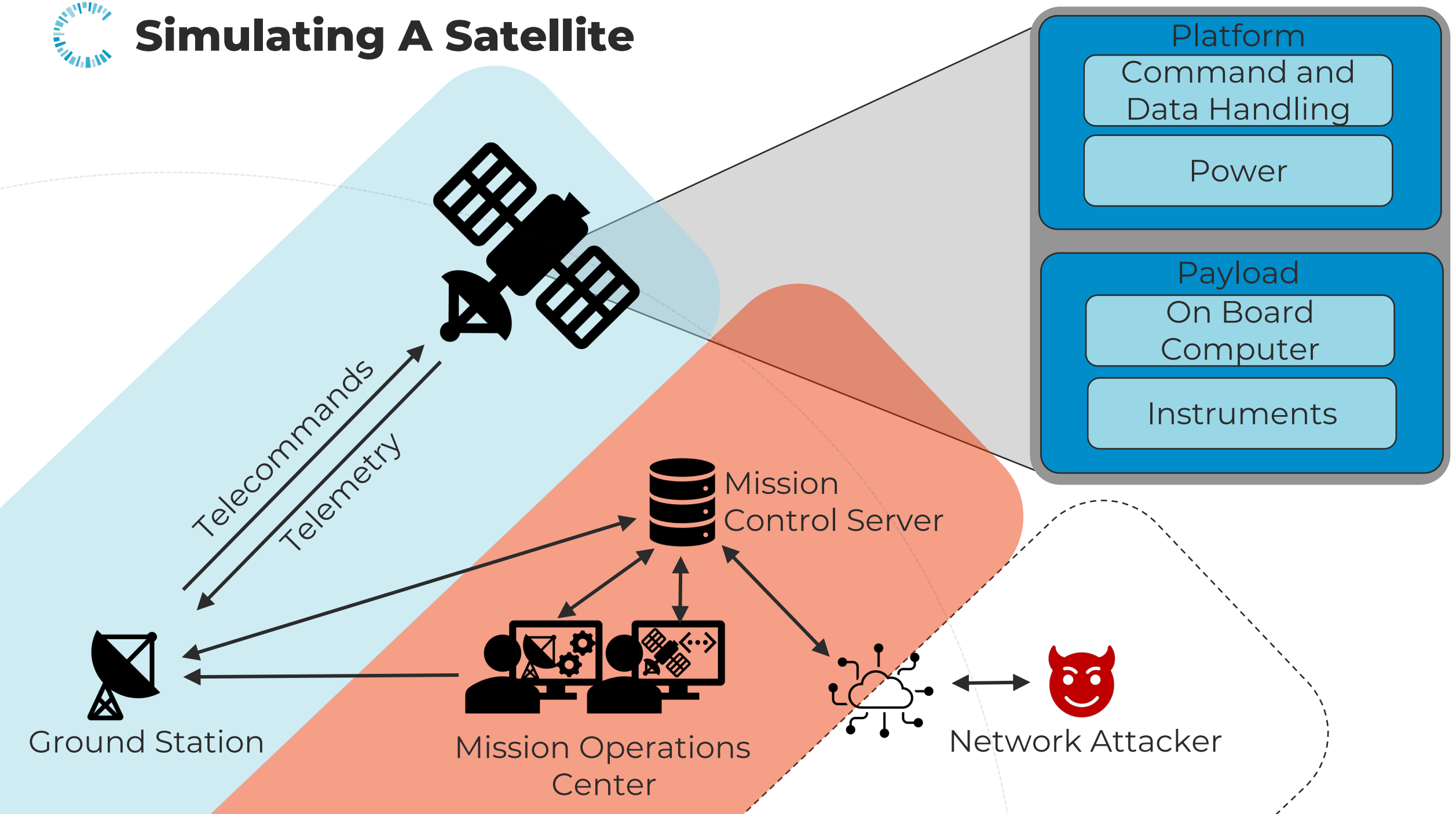
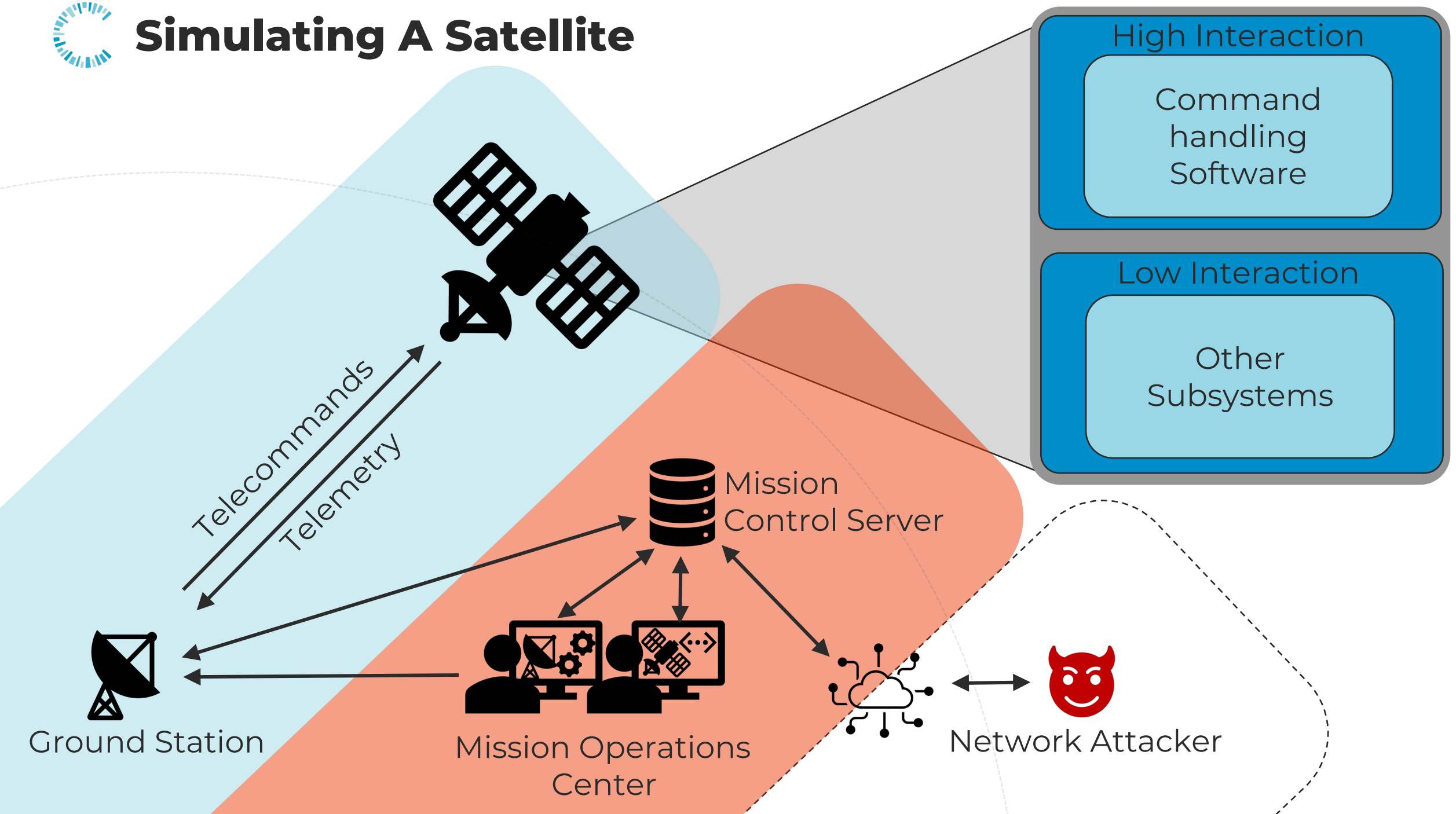
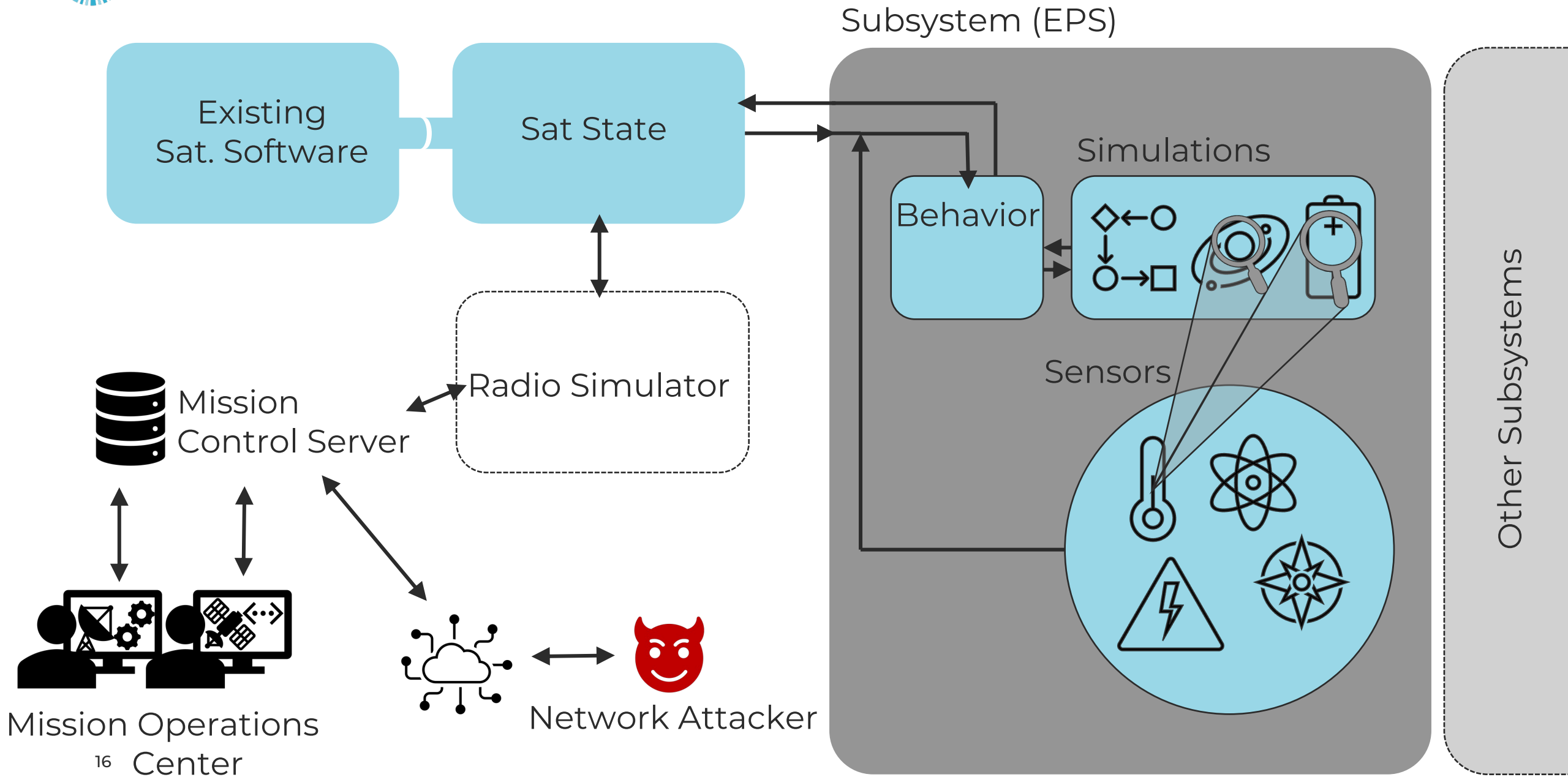
Simulating A Satellite



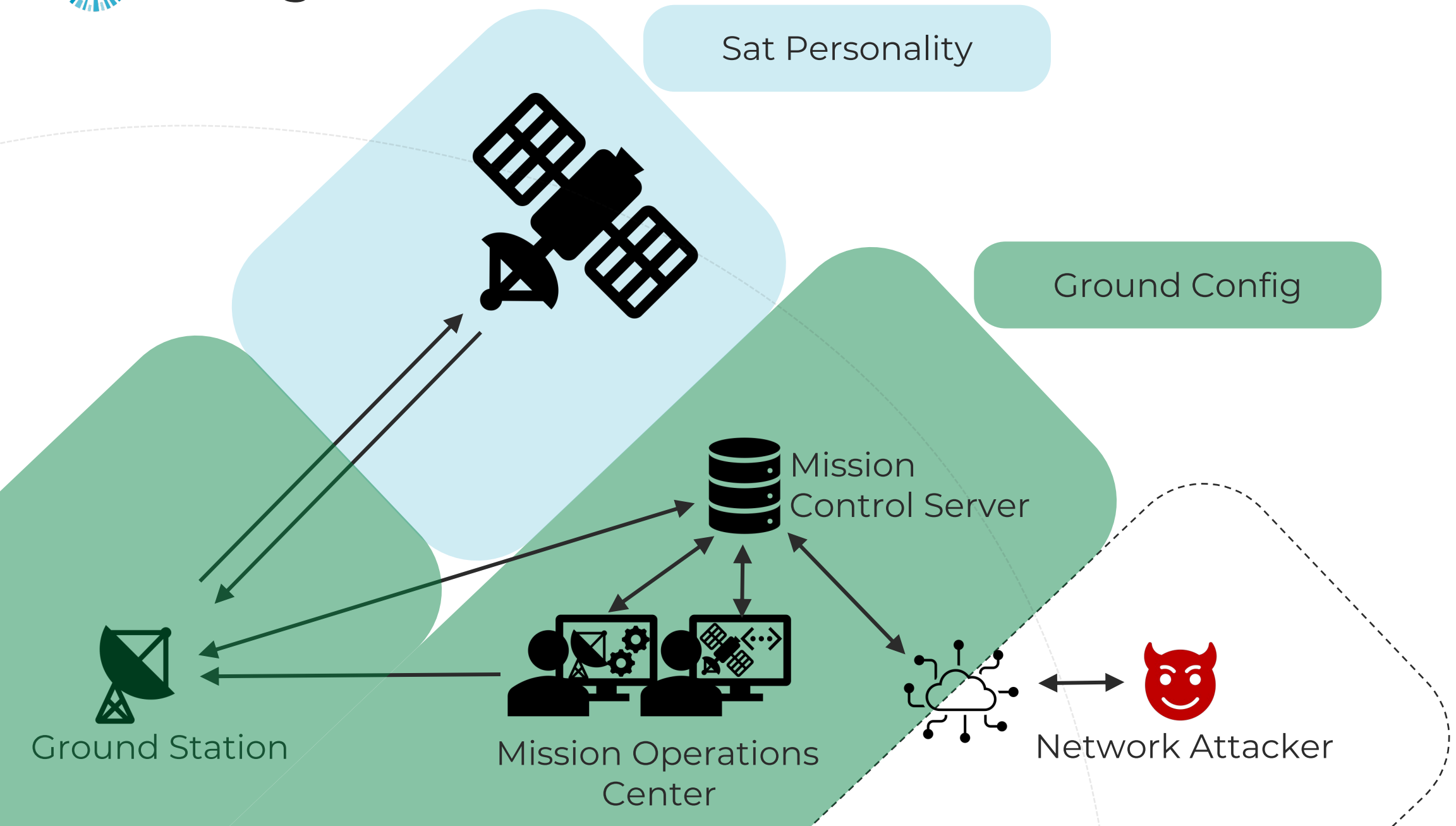
Simulating A Satellite



Delivering Believable Spacecraft



Configuration



Delivering Believable Ground Infrastructure

- Operator **workstation** with Remote Desktop

Delivering Believable Ground Infrastructure

- Operator **workstation** with Remote Desktop
- Network with **Mission Control Server** and **Ground Station**

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Delivering Believable Ground Infrastructure

- Operator **workstation** with Remote Desktop
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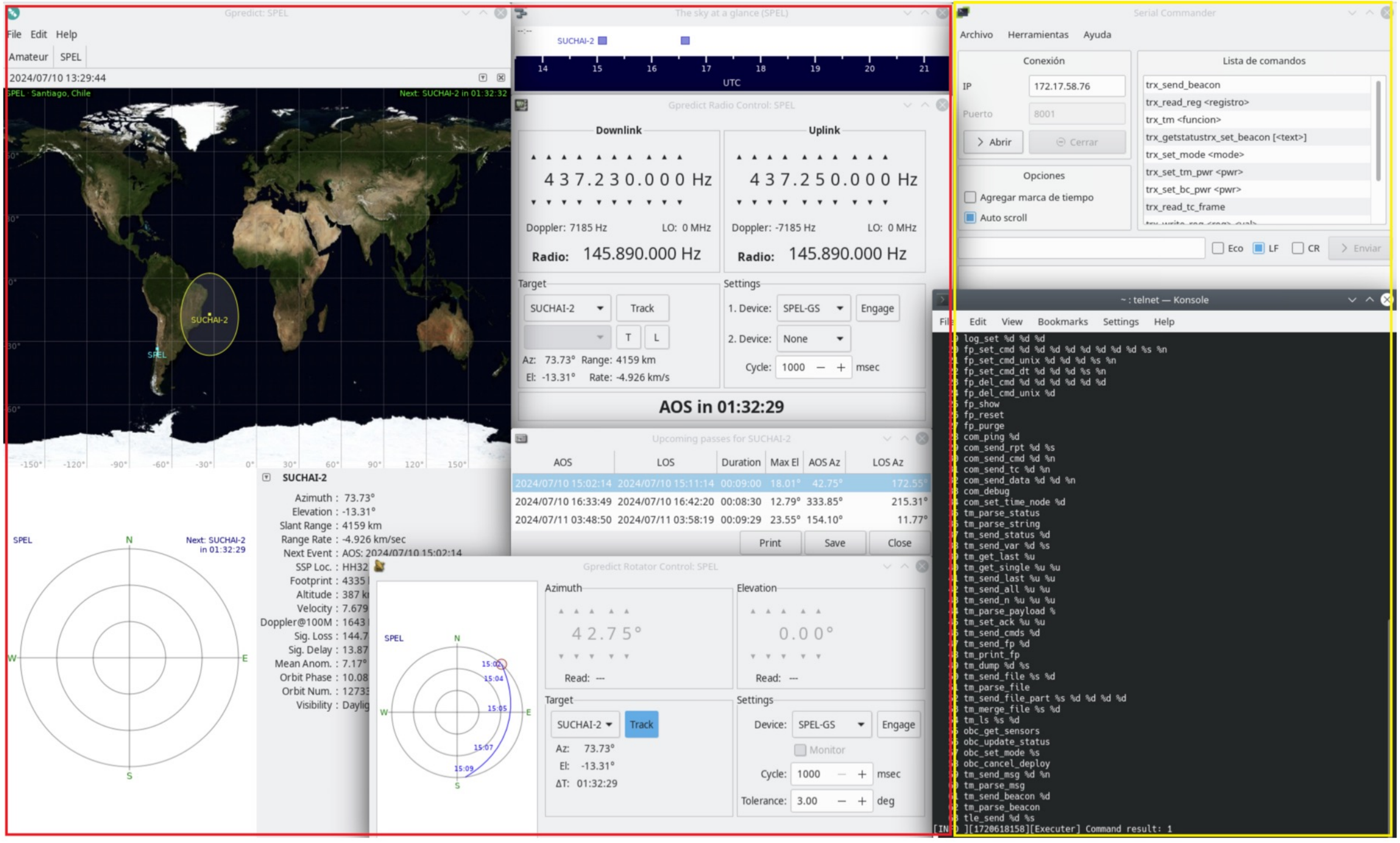
- **Mission Control Client**
- **Ground Station Control Software**
- **Standard** Operational **tools** bundled for Realism


Gpredict: SPEL
File Edit Help
Amateur SPEL
2024/07/10 13:29:44
SPEL · Santiago, Chile
Next: SUCHAI-2 in 01:32:32
SUCHAI-2
SPEL
The sky at a glance (SPEL)
SUCHAI-2
14 15 16 17 18 19 20 21
UTC
Gpredict Radio Control: SPEL
Downlink
437.230.000 Hz
Doppler: 7185 Hz
LO: 0 MHz
Radio: 145.890.000 Hz
Uplink
437.250.000 Hz
Doppler: -7185 Hz
LO: 0 MHz
Radio: 145.890.000 Hz
Target
SUCHAI-2
Track
T
L
Az: 73.73° Range: 4159 km
El: -13.31° Rate: -4.926 km/s
Settings
1. Device: SPEL-GS
Engage
2. Device: None
Cycle: 1000 msec
AOS in 01:32:29
Upcoming passes for SUCHAI-2
AOS LOS Duration Max El AOS Az LOS Az
2024/07/10 15:02:14 2024/07/10 15:11:14 00:09:00 18.01° 42.75° 172.55°
2024/07/10 16:33:49 2024/07/10 16:42:20 00:08:30 12.79° 333.85° 215.31°
2024/07/11 03:48:50 2024/07/11 03:58:19 00:09:29 23.55° 154.10° 11.77°
Print
Save
Close
SUCHAI-2
Azimuth : 73.73°
Elevation : -13.31°
Slant Range : 4159 km
Range Rate : -4.926 km/sec
Next Event : AOS: 2024/07/10 15:02:14
SSP Loc. : HH32
Footprint : 4335
Altitude : 387 k
Velocity : 7.679
Doppler@100M : 1643
Sig. Loss : 144.7
Sig. Delay : 13.87
Mean Anom. : 7.17°
Orbit Phase : 10.08
Orbit Num. : 1273
Visibility : Daylig
SPEL
Next: SUCHAI-2 in 01:32:29
N
W
E
S
Gpredict Rotator Control: SPEL
Azimuth
42.75°
Read: ---
Elevation
0.00°
Read: ---
Target
SUCHAI-2
Track
Az: 73.73°
El: -13.31°
ΔT: 01:32:29
Settings
Device: SPEL-GS
Engage
Monitor
Cycle: 1000 msec
Tolerance: 3.00 deg
15:02
15:04
15:05
15:07
15:09
Serial Commander
Archivo Herramientas Ayuda
Conexión
IP 172.17.58.76
Puerto 8001
Abrir
Cerrar
Opciones
Agregar marca de tiempo
Auto scroll
Lista de comandos
trx_send_beacon
trx_read_reg <registro>
trx_tm <funcion>
trx_getstatustrx_set_beacon [<text>]
trx_set_mode <mode>
trx_set_tm_pwr <pwr>
trx_set_bc_pwr <pwr>
trx_read_tc_frame
Eco
LF
CR
Enviar
~ : telnet — Konsole
File Edit View Bookmarks Settings Help
log_set %d %d %d
fp_set_cmd %d %d %d %d %d %d %d %d %s %n
fp_set_cmd_unix %d %d %d %s %n
fp_set_cmd_dt %d %d %d %s %n
fp_del_cmd %d %d %d %d %d %d
fp_del_cmd_unix %d
fp_show
fp_reset
fp_purge
com_ping %d
com_send_rpt %d %s
com_send_cmd %d %n
com_send_tc %d %n
com_send_data %d %d %n
com_debug
com_set_time_node %d
tm_parse_status
tm_parse_string
tm_send_status %d
tm_send_var %d %s
tm_get_last %u
tm_get_single %u %u
tm_send_last %u %u
tm_send_all %u %u
tm_send_n %u %u %u
tm_parse_payload %
tm_set_ack %u %u
tm_send_cmds %d
tm_send_fp %d
tm_print_fp
tm_dump %d %s
tm_send_file %s %d
tm_parse_file
tm_send_file_part %s %d %d %d %d
tm_merge_file %s %d
tm_ls %s %d
obc_get_sensors
obc_update_status
obc_set_mode %s
obc_cancel_deploy
tm_send_msg %d %n
tm_parse_msg
tm_send_beacon %d
tm_parse_beacon
tle_send %d %s
][1720618158][Executer] Command result: 1

Evaluation

- **10 experienced** SmallSat **operators** (1–10 years; 1–5 missions; diverse regions/sectors)
- **Overall realism**: 90% agreed they “would not be able to distinguish” HoneySat from the real mission.
- We support interactions for **33 / 38 SPACE-SHIELD techniques**

Point of Entry

- Website with **weak credentials** as initial **entry point**

- **Multiple entry styles** tested:
  1. Web-based mission control interface
  2. Ground-station appliance config page
  3. Internal “mission” website

- **Best-performing lure**: a Django based mission-style website with documentation + remote-desktop credentials to entice access

Deployments

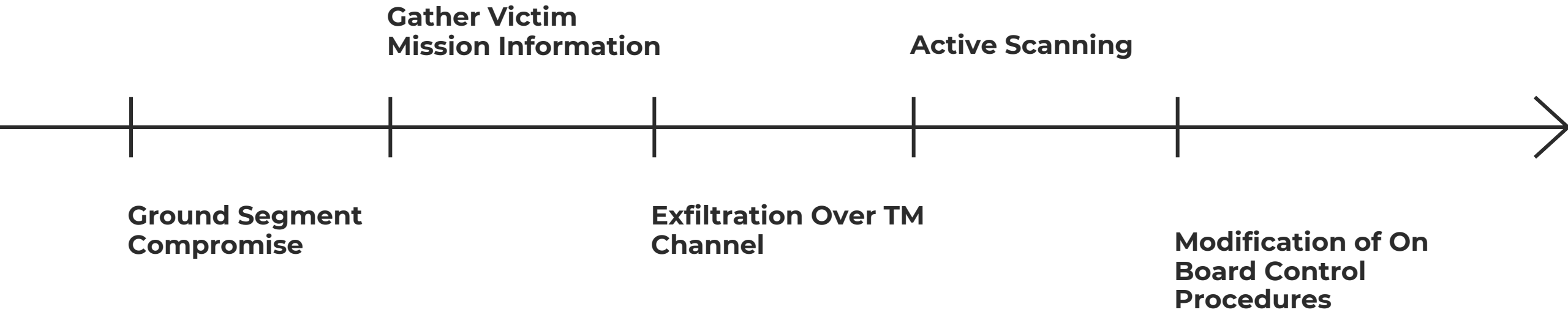
Deployment	Sat. Personality	Real Mission Owner	HoneySat Region	Duration (months)
Cloud	PIXL-1	DLR	Germany	6
Cloud	PIXL-1	DLR	Germany	6
Cloud	ACS3	NASA	USA	6
Cloud	ACS3	NASA	USA	6
On-prem	SUCHAI-2	SPEL	University of Chile	12

Interactions

Date	Mission	HoneySat Region	Attacker Geo IP
Jan 18, 2025	ACS3	USA	Egypt
Jan 24, 2025	PIXL-1	Germany	Tor
Jan 24, 2025	ACS3	USA	Tor
Apr 3, 2025	ACS3	USA	USA

Attacker Behavior

All Attackers interacting with the MCS Performed **Spacecraft's Components Discovery**



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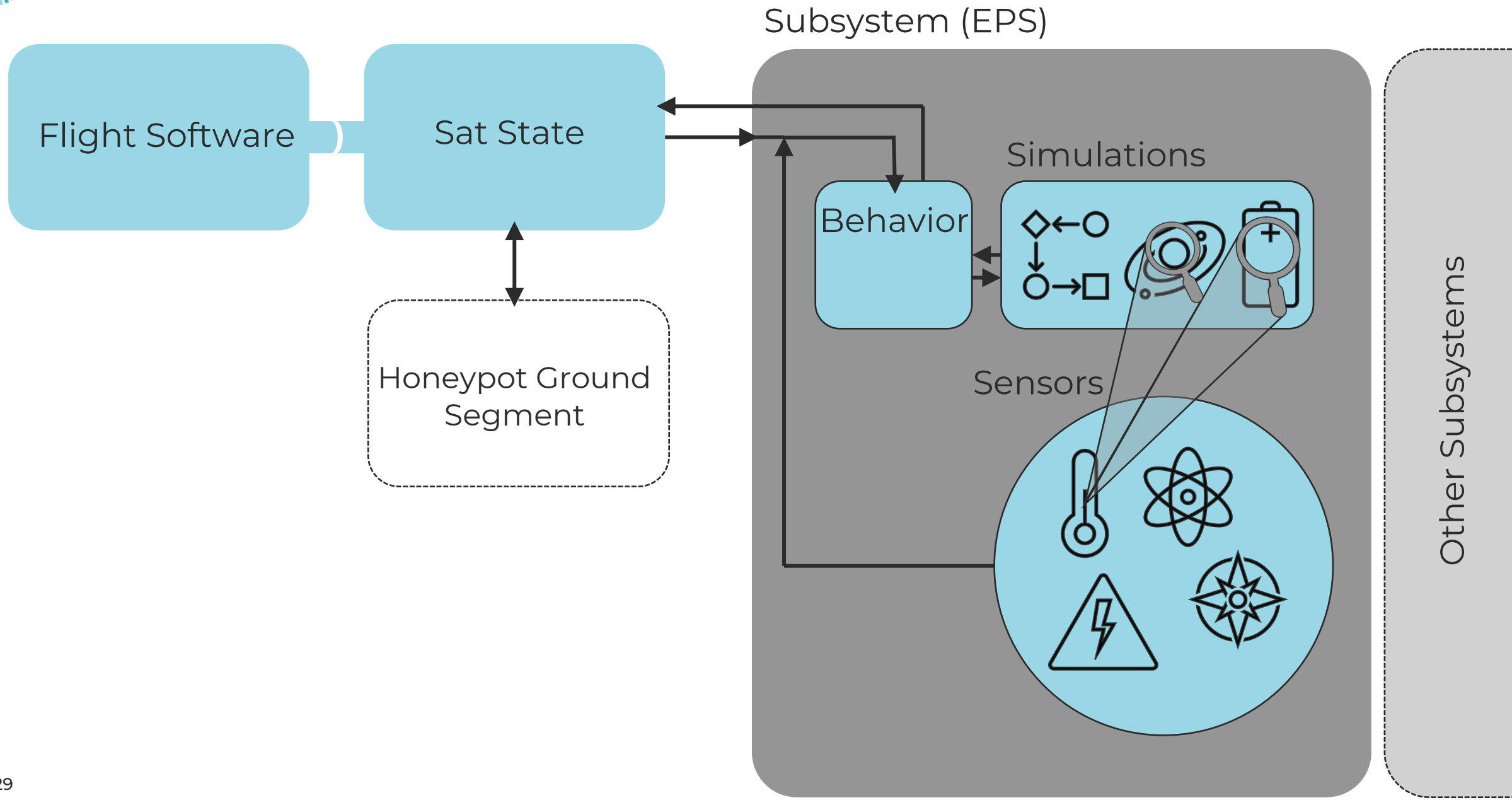

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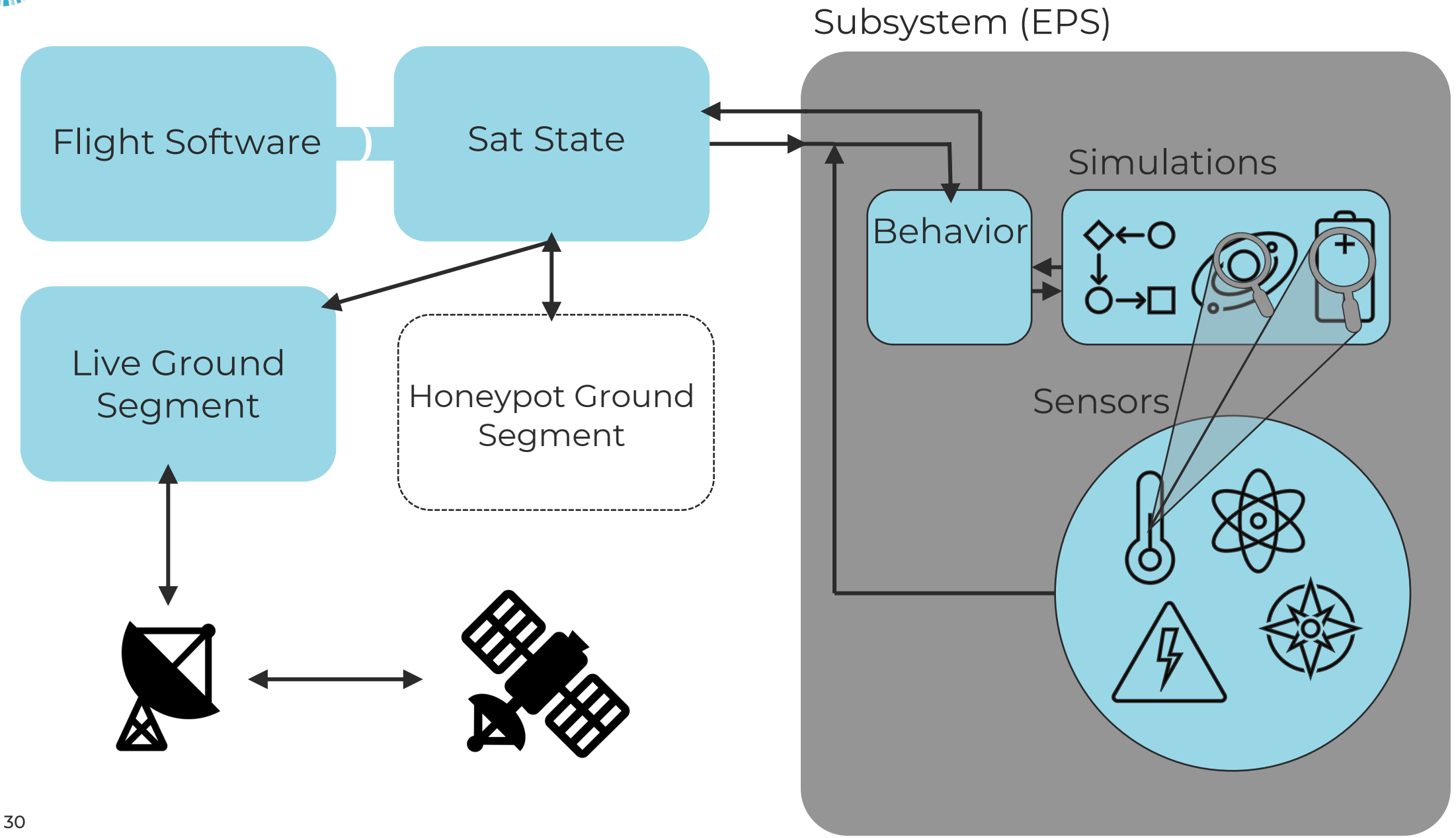
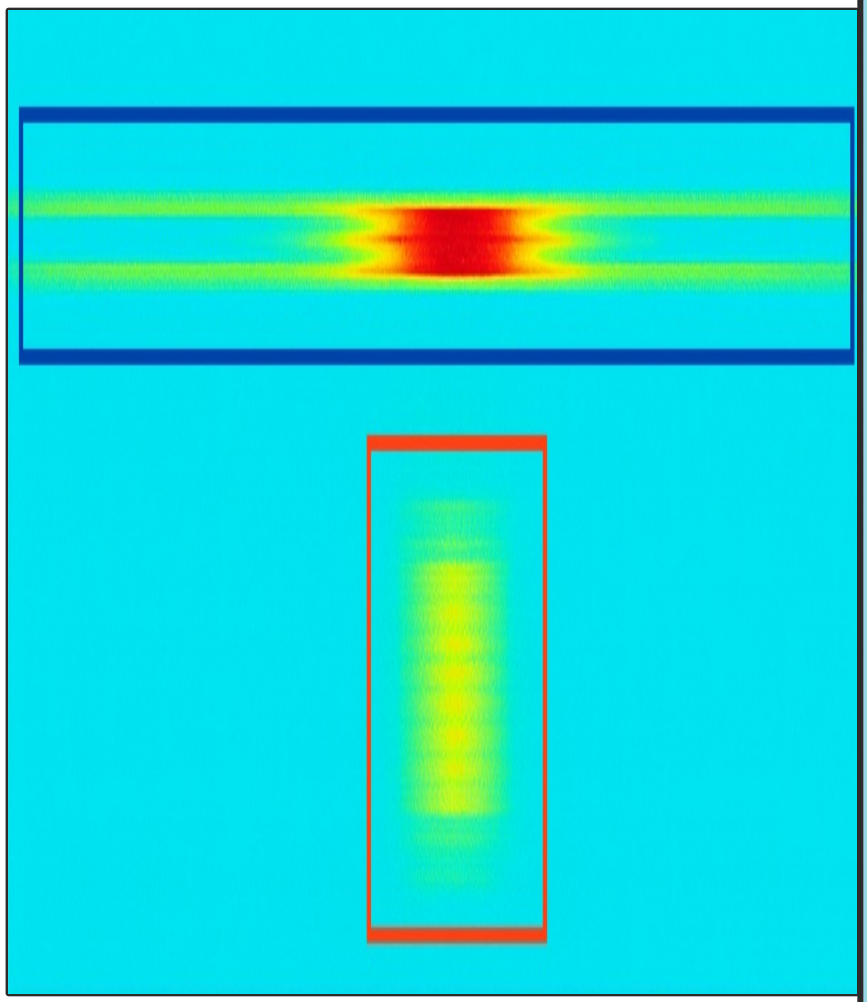
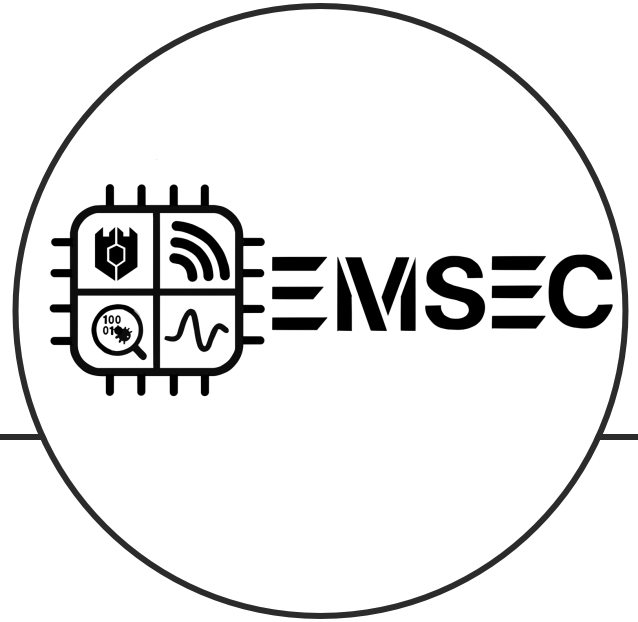




Satellite In The Loop

Deceiving attackers observing the real Ground Station

Q & A



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