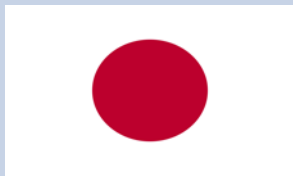




# BIRDS-4

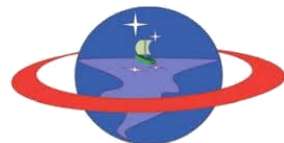
JOINT GLOBAL MULTI-NATION BIRDS  
SATELLITE PROJECT



# BIRDS open-source operation software



**Kyutech**  
Kyushu Institute of Technology



**La SEINE**

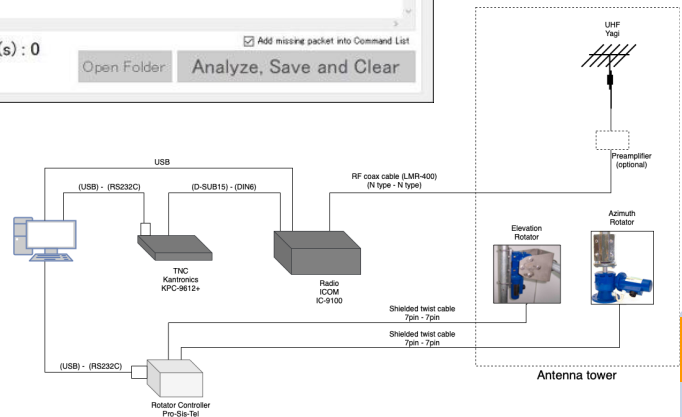
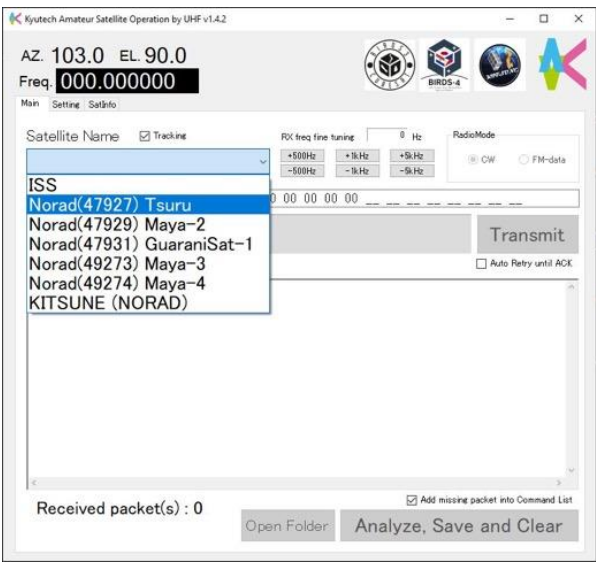
BIRDS BUS Open-source Webinar #6  
(May 14 22:00 JST)

D3 student, Daisuke Nakayama

Kyushu Institute of Technology LaSEINE

# Index

- Background (history)
- Hardware block diagram
- Software setting
- Operation
  - Select a satellite
  - Send a command
  - Receive packets
- Supporting function
  - Frequency Control
  - Antenna Direction Control
- Summary



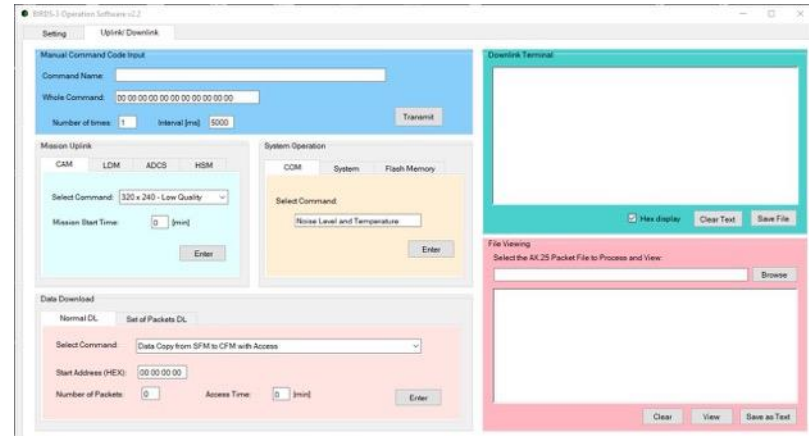
# History of Open-source “BIRDS-GS\_software”

## □ Until BIRDS-3: dedicated software

- Command generation and Analysis function for each mission
- Issue: BIRDS-4 project has many missions
  - BIRDS-3: 3 missions
  - BIRDS-4: 9 missions

## □ Difficulty

- Complexity of command generator.
- More efficient operation is required.



BIRDS-3 operation software



Kyutech  
Kyushu Institute of Technology



La SEINE

# History of Open-source "BIRDS-GS\_software"

## □ BIRDS-4 project develop an operation software

- Command list function
  - Command is generated by the mission team.
  - Missing packet collection is easy to implement.
- Doppler shift correction and tracking functions
  - No reliance on external software e.g., SatPC32
  - Quickly switch between multiple satellite operations

| A                             | B   | C         |
|-------------------------------|---|-----------|
| May 1 (Sunday)                | 23:33:33.84mg   |           |
| XX XX XX XX XX XX XX XX XX XX | Download TMCR address pointer                           | Tsuru OK  |
| XX XX XX XX XX XX XX XX XX XX | Download HIGH SAMP data Set 6 (StartAdd : 06 A2 7C DB)  | Tsuru OK  |
| XX XX XX XX XX XX XX XX XX XX | Download HIGH SAMP data Set 7 (StartAdd : 06 A2 7C DB)  | Tsuru OK  |
| XX XX XX XX XX XX XX XX XX XX | Download HIGH SAMP data Set 8 (StartAdd : 06 A2 7C DB)  | Tsuru OK  |
| XX XX XX XX XX XX XX XX XX XX | Download HIGH SAMP data Set 9 (StartAdd : 06 A2 7C DB)  | Tsuru OK  |
| XX XX XX XX XX XX XX XX XX XX | Download HIGH SAMP data Set 10 (StartAdd : 06 A2 7C DB) | Tsuru OK  |
| XX XX XX XX XX XX XX XX XX XX | Download ADCS data Set 1 (StartAdd : 04 72 74 54)       | Tsuru OK  |
| May 2 (Monday)                | 23:57:49.26mg   | > Esteban |

Kyutech Amateur Satellite Operation by UHF v1.4.2

AZ 103.0 EL 90.0  
Freq 000.000000

Satellite Name: ISS  
 Norad(47927) Tsuru  
 Norad(47929) Maya-2  
 Norad(47931) GuaranSat-1  
 Norad(49273) Maya-3  
 Norad(49274) Maya-4  
 KITSUNE (NORAD)

Received packet(s) : 0

Buttons: Transmit, Open Folder, Analyze, Save and Clear

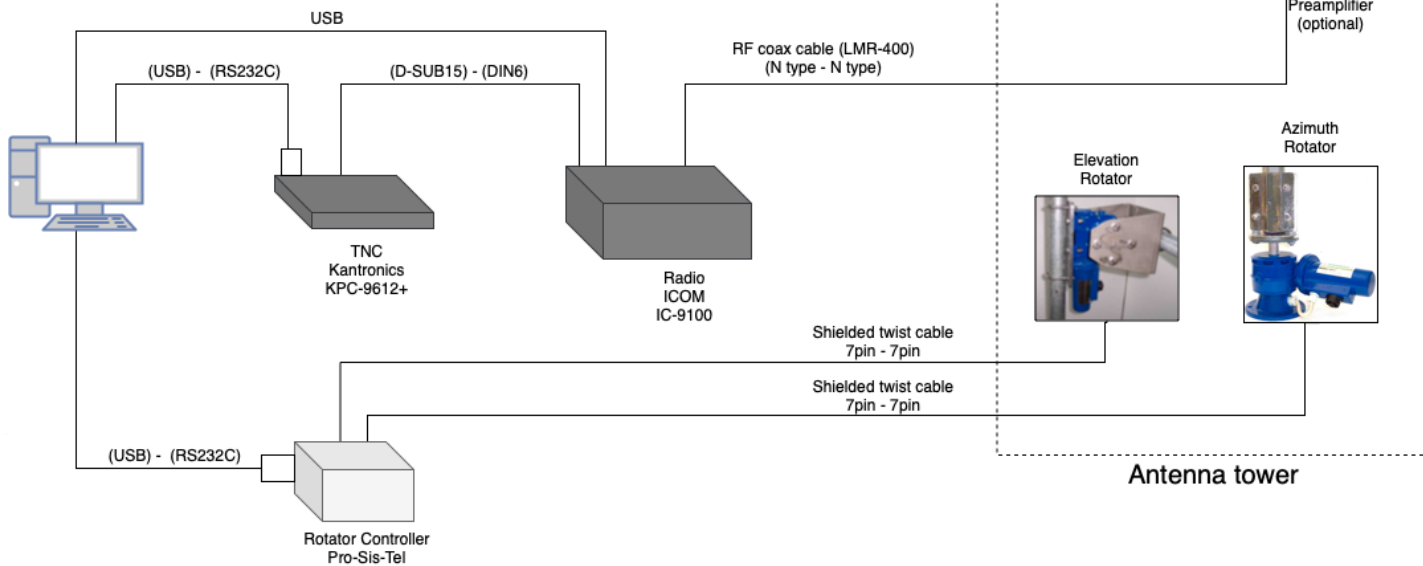




# Hardware block diagram



IC-9100 and KPC-9612+



20-element cross Yagi antenna x 2

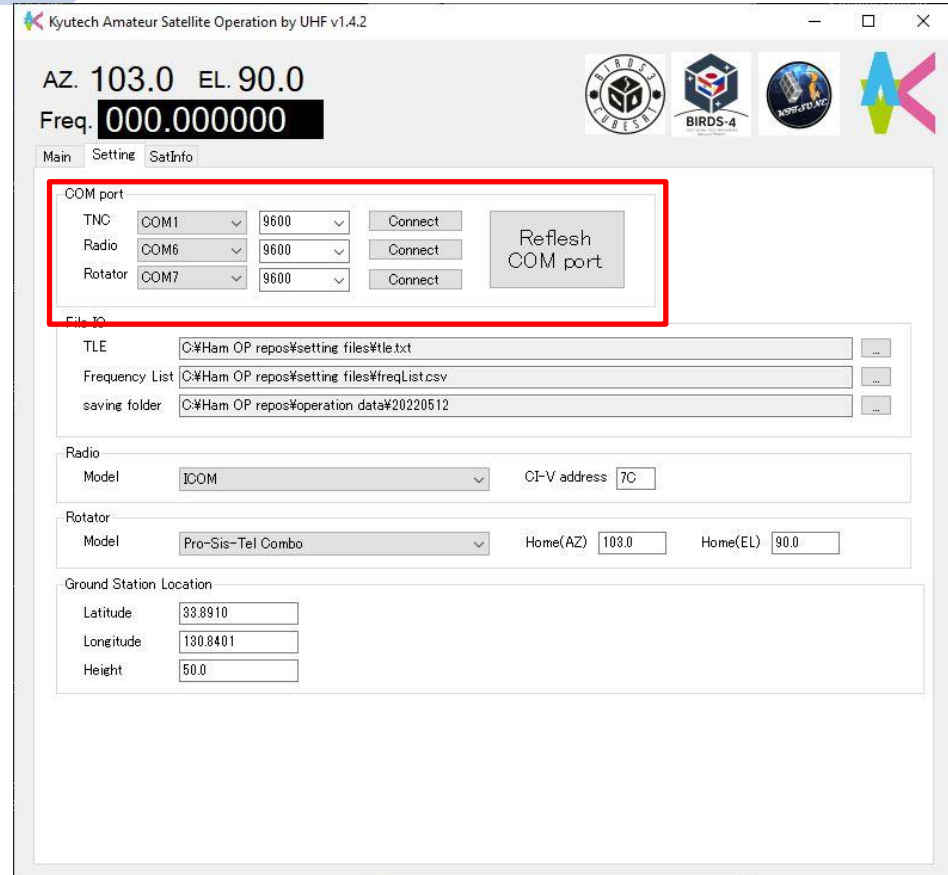


Rotator Controller

- Auto-loaded file path
  - TLE\*
  - Frequency List
- Folder path for Auto-Saved files
  - Raw file, log, packet(banally) etc...
- Radio (CI-V address)
- Rotator
  - PRO-SIS-TEL / YAESU
  - Home position
- GS Position
  - Latitude, Longitude and Height

# Setting example (Kyutech amateur station)

- The COM port is set every time the software is started.
  - Other settings in this tab are saved in the software, so you don't need to change after once you set.



Kyutech Amateur Satellite Operation by UHF v1.4.2

AZ. 103.0 EL. 90.0  
Freq. 000.000000

Main Setting SatInfo

COM port

|         |      |      |         |                     |
|---------|------|------|---------|---------------------|
| TNC     | COM1 | 9600 | Connect | Refresh<br>COM port |
| Radio   | COM6 | 9600 | Connect |                     |
| Rotator | COM7 | 9600 | Connect |                     |

File IO

TLE C:\Ham OP repos\setting files\tle.txt ...

Frequency List C:\Ham OP repos\setting files\freqList.csv ...

saving folder C:\Ham OP repos\operation data\20220512 ...

Radio

Model ICOM CI-V address 7C

Rotator

Model Pro-Sis-Tel Combo Home(AZ) 103.0 Home(EL) 90.0

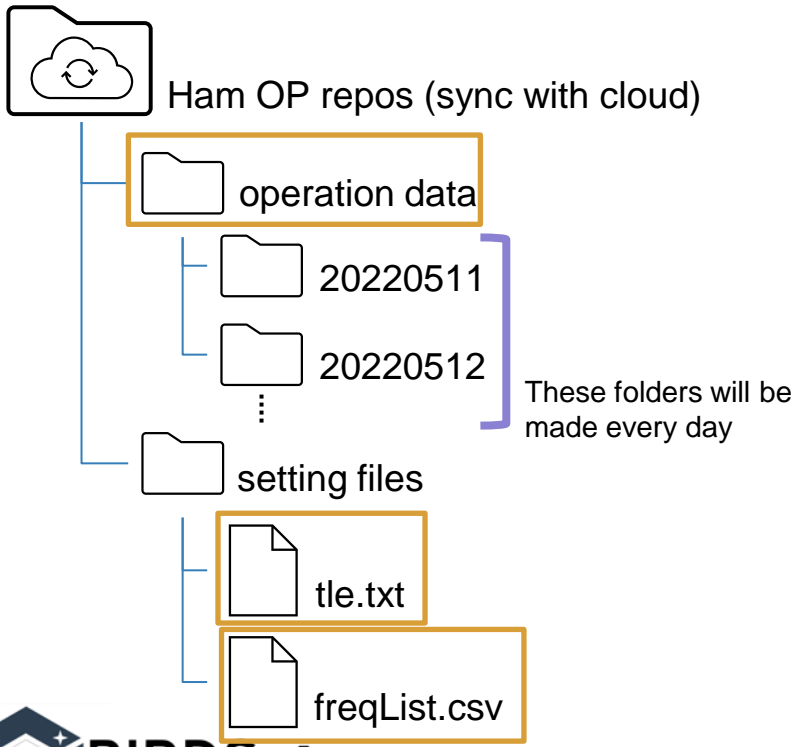
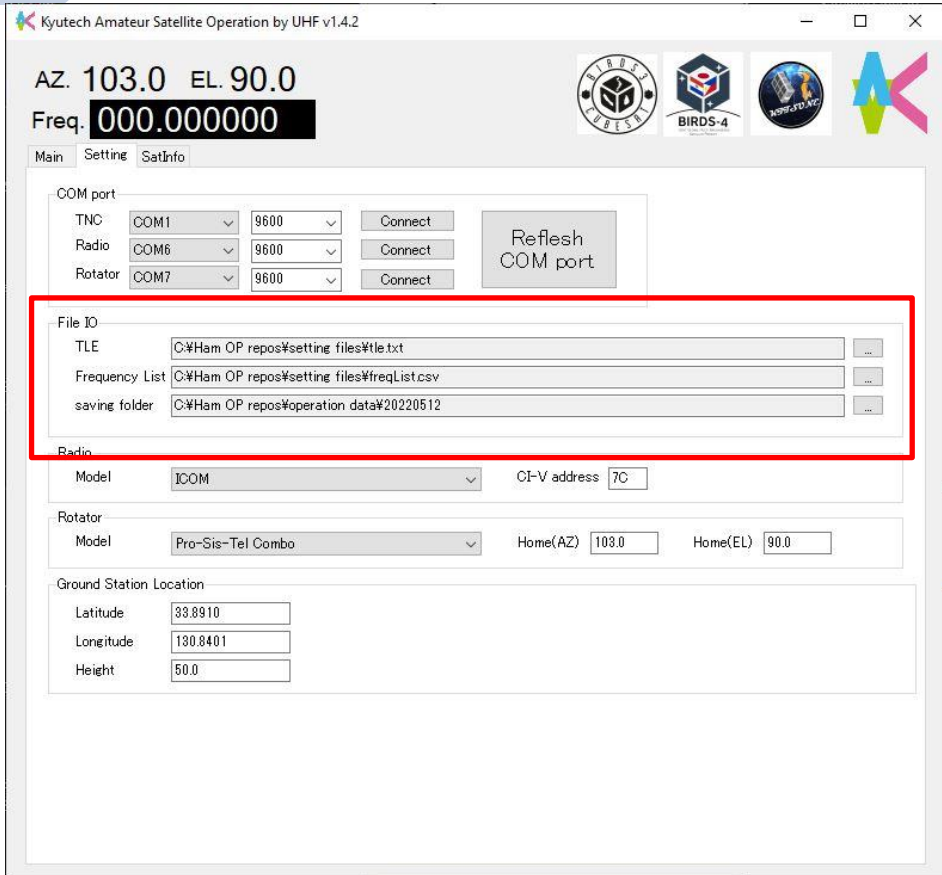
Ground Station Location

Latitude 33.8910

Longitude 130.8401

Height 50.0

# Setting example (Kyutech amateur station)

Kyutech Amateur Satellite Operation by UHF v1.4.2

AZ. 103.0 EL. 90.0  
 Freq: 000.000000

Main Setting SatInfo

COM port

TNC COM1 9600 Connect

Radio COM6 9600 Connect

Rotator COM7 9600 Connect

Refresh COM port

File IO

TLE C:\Ham OP repos\setting files\tle.txt

Frequency List C:\Ham OP repos\setting files\freqList.csv

saving folder C:\Ham OP repos\operation data\20220512

Radio

Model ICOM CI-V address 7C

Rotator

Model Pro-Sis-Tel Combo Home(AZ) 103.0 Home(EL) 90.0

Ground Station Location

Latitude 33.8910

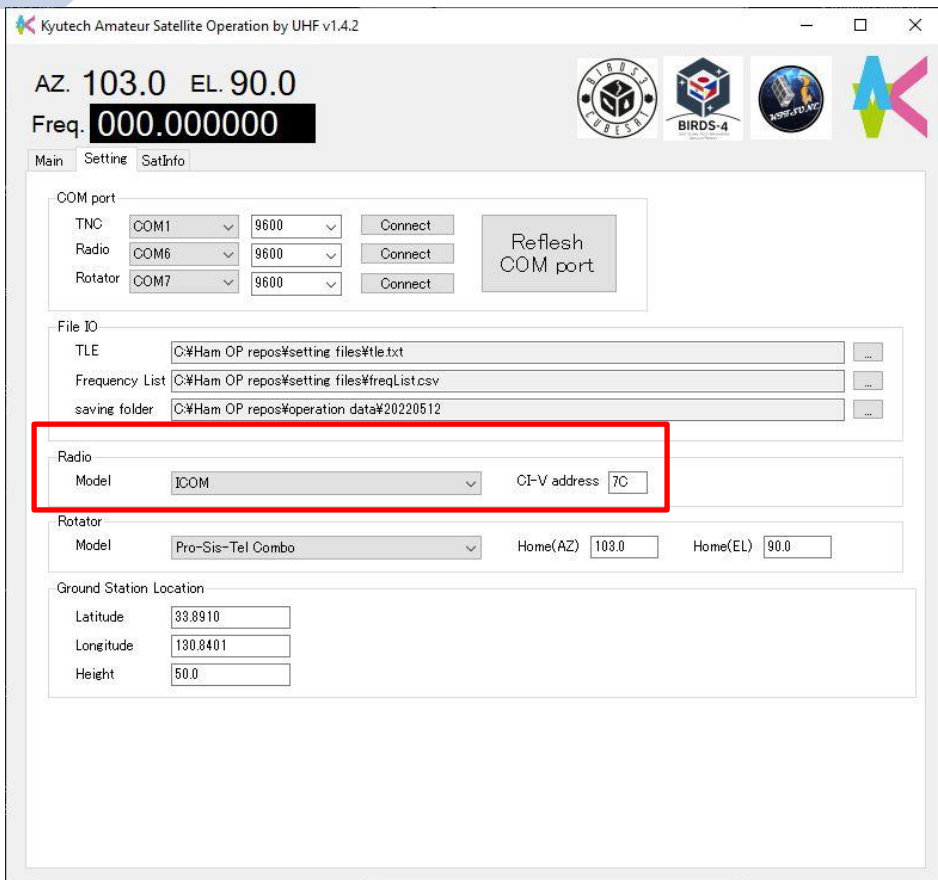
Longitude 130.8401

Height 50.0



# Setting example (Kyutech amateur station)

- Select the radio manufacture
  - Only ICOM for open-source
- Select CI-V address
  - Refer the radio manual.
  - IC-9100 default: 7C



Kyutech Amateur Satellite Operation by UHF v1.4.2

AZ: 103.0 EL: 90.0  
 Freq: 000.000000

Main Setting SatInfo

COM port

TNC COM1 9600 Connect

Radio COM6 9600 Connect

Rotator COM7 9600 Connect

Refresh COM port

File IO

TLE C:\Ham OP repos\setting files\tle.txt

Frequency List C:\Ham OP repos\setting files\freqList.csv

saving folder C:\Ham OP repos\operation data\#20220512

Radio

Model ICOM CI-V address 7C

Rotator

Model Pro-Sis-Tel Combo Home(AZ) 103.0 Home(EL) 90.0

Ground Station Location

Latitude 33.8910

Longitude 130.8401

Height 50.0

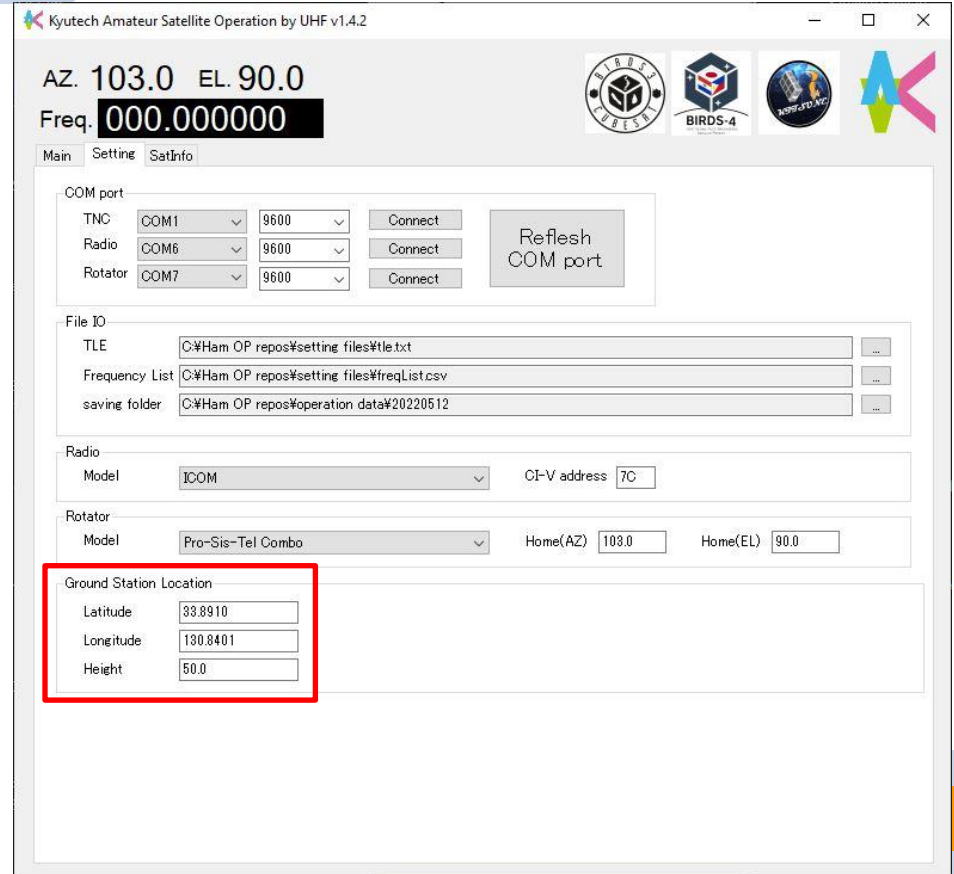
# Setting example (Kyutech amateur station)

- ❑ Select the radio manufacture
  - Pro-Sis-Tel Combo
  - YAESU G-5500
- ❑ Set home position
  - When the satellite is less than -10 deg elevation, the antenna become this position.

# Setting example (Kyutech amateur station)

## □ Set the ground station position

- Latitude [deg]
- Longitude [deg]
- Height [m]



Kyutech Amateur Satellite Operation by UHF v1.4.2

AZ. 103.0 EL. 90.0  
Freq. 000.000000

Main Setting SatInfo

COM port

|         |      |      |         |
|---------|------|------|---------|
| TNC     | COM1 | 9600 | Connect |
| Radio   | COM6 | 9600 | Connect |
| Rotator | COM7 | 9600 | Connect |

Refresh COM port

File IO

|                |  |
|----------------|--|
| TLE            | C:\Ham OP repos\setting files\tle.txt      |
| Frequency List | C:\Ham OP repos\setting files\freqList.csv |
| saving folder  | C:\Ham OP repos\operation data\#20220512   |

Radio

|       |      |              |    |
|-------|------|--------------|----|
| Model | ICOM | CI-V address | 7C |
|-------|------|--------------|----|

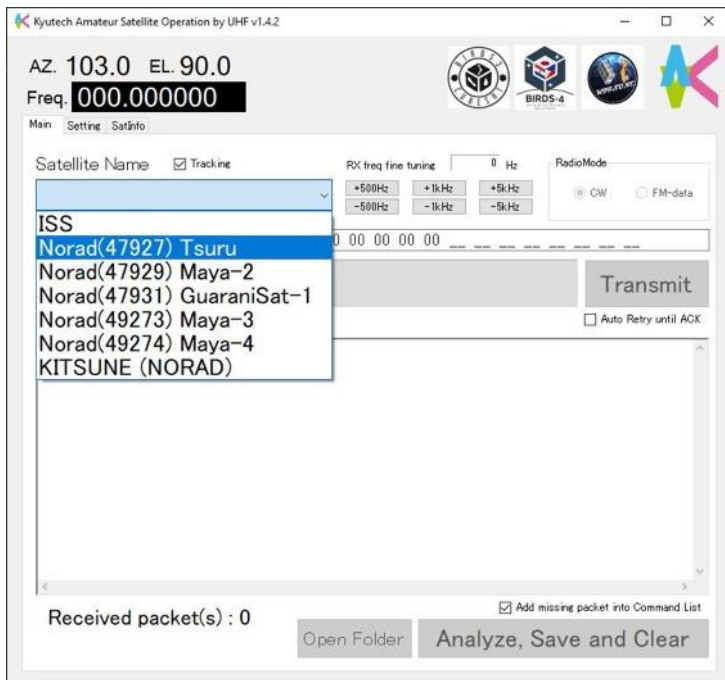
Rotator

|       |                   |          |       |          |      |
|-------|-------------------|----------|-------|----------|------|
| Model | Pro-Sis-Tel Combo | Home(AZ) | 103.0 | Home(EL) | 90.0 |
|-------|-------------------|----------|-------|----------|------|

Ground Station Location

|           |          |
|-----------|----------|
| Latitude  | 33.8910  |
| Longitude | 130.8401 |
| Height    | 50.0     |

# Select a satellite



## freqList.csv

|    | A                         | B       | C         | D         | E         | F                | G           |
|----|---------------------------|---------|-----------|-----------|-----------|------------------|-------------|
| 1  | SatelliteName             | NoradID | CW beacn  | Uplink    | Downlink  | Remark           | Folder name |
| 2  | Norad(47927) Tsuru        | 47927   | 437375000 | 435xxxxxx | 437375000 | Norad            | Tsuru       |
| 3  | Norad(47929) Maya-2       | 47929   | 437375000 | 435xxxxxx | 437375000 | Norad            | Maya2       |
| 4  | Norad(47931) GuaraniSat-1 | 47931   | 437375000 | 435xxxxxx | 437375000 | Norad            | GuaraniSat1 |
| 5  | HORYU-IV                  | 41340   | 437375000 | 435xxxxxx | 437375000 | HORYU4           | HORYU4      |
| 6  | KOSEN-1                   | 99991   | 435525000 | 435xxxxxx | 435525000 | KOSEN-1          | KOSEN-1     |
| 7  | ISS                       | 25544   | 437375000 | 435xxxxxx | 437375000 | ISS              | ISS         |
| 8  | Norad(49273) Maya-3       | 49273   | 437375000 | 435xxxxxx | 437375000 | Deployed at 10/6 | Maya3       |
| 9  | Norad(49274) Maya-4       | 49274   | 437375000 | 435xxxxxx | 437375000 | Deployed at 10/6 | Maya4       |
| 10 | KITSUNE (NORAD)           | 52148   | 437375000 | 435xxxxxx | 437375000 | KITSUNE          | KITSUNE     |

## tle.txt

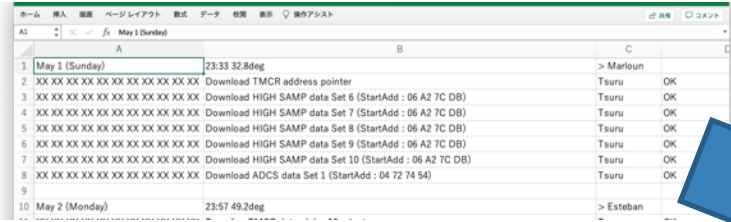
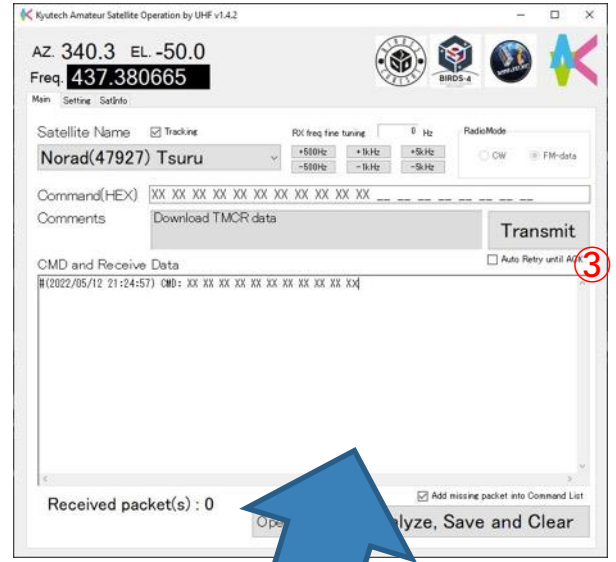
\*Update everyday

```
tle.txt
0 ISS (ZARYA)
1 25544U 98067A 22132.35300373 .00005928 00000-0 11162-3 0 9992
2 25544 51.6429 154.0493 0006869 88.6298 34.7251 15.50035239339623
0 TSURU
1 47927U 98067SD 22131.04702293 .00137611 00000-0 79184-3 0 9996
2 47927 51.6333 136.5953 0006455 44.9957 315.1565 15.77760239 65860
0 MAYA-2
1 47929U 98067SF 22132.18823934 .00142389 00000-0 81518-3 0 9992
2 47929 51.6332 130.7148 0006269 51.7447 308.4117 15.77859573 66003
0 GUARANISAT-1
1 47931U 98067SH 22132.17288133 .00148307 00000-0 83746-3 0 9991
2 47931 51.6310 130.6294 0006088 50.0009 310.1526 15.78148920 66042
0 MAYA-3
1 49273U 98067SS 22132.14765912 .00101970 00000-0 83668-3 0 9992
2 49273 51.6343 143.9381 0004505 54.1797 305.9618 15.69648927 34001
0 MAYA-4
1 49274U 98067ST 22132.16157975 .00100244 00000-0 83271-3 0 9992
2 49274 51.6340 144.0278 0004540 54.9673 305.1750 15.69358096 34000
0 KITSUNE
1 52148U 98067TK 22132.17116032 .00019481 00000-0 31787-3 0 9993
2 52148 51.6427 154.4325 0003948 101.6814 335.8982 15.52589207 7601
```

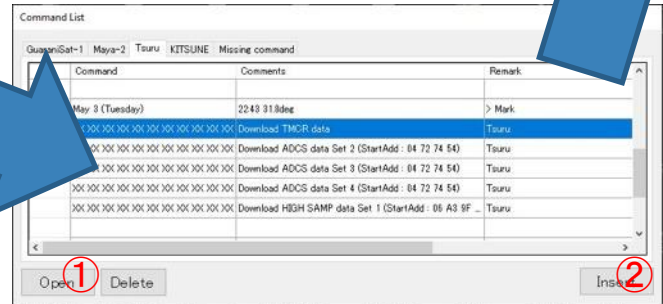
# Send a command

## Command list system

- Command list is edited on a separate software or spreadsheet.
- Another project using the same bus, KITSUNE (6U CubeSat), is also in use with only some modifications.



| Date           | Time          | Command  |
|----------------|---------------|--|
| May 1 (Sunday) | 23:33 32.8deg | > Marloun  |
|                |               | Download TMCR address pointer Tsuru OK                           |
|                |               | Download HIGH SAMP data Set 6 (StartAdd : 06 A2 7C DB) Tsuru OK  |
|                |               | Download HIGH SAMP data Set 7 (StartAdd : 06 A2 7C DB) Tsuru OK  |
|                |               | Download HIGH SAMP data Set 8 (StartAdd : 06 A2 7C DB) Tsuru OK  |
|                |               | Download HIGH SAMP data Set 9 (StartAdd : 06 A2 7C DB) Tsuru OK  |
|                |               | Download HIGH SAMP data Set 10 (StartAdd : 06 A2 7C DB) Tsuru OK |
|                |               | Download ADCS data Set 1 (StartAdd : 04 72 74 54) Tsuru OK       |
| May 2 (Monday) | 23:57 49.2deg | > Esteban  |



| Command  | Comments   | Remark |
|--|--|--------|
| GuassiniSat-1 Mays-2 Tsuru : KITSUNE Missing command |  |        |
| May 3 (Tuesday)                                      | 22:43 31.8deg                                      | > Mark |
|  | Download TMCR data                                 | Tsuru  |
|  | Download ADCS data Set 2 (StartAdd : 04 72 74 54)  | Tsuru  |
|  | Download ADCS data Set 3 (StartAdd : 04 72 74 54)  | Tsuru  |
|  | Download ADCS data Set 4 (StartAdd : 04 72 74 54)  | Tsuru  |
|  | Download HIGH SAMP data Set 1 (StartAdd : 06 A3 8F | Tsuru  |



# Receive packets

Open Birds Operation beta

AZ. 034.9 EL. -30.1  
Freq. 437.371029

Main Setting SatInfo

Satellite Name  Tracking  
Norad(47927) Tsuru

RX freq fine tuning 0 Hz  
+500Hz +1kHz +5kHz  
-500Hz -1kHz -5kHz

RadioMode  
 CW  FM-data

Command(HEX) XX XX XX XX XX XX XX XX XX XX  
Comments None

CMD and Receive Data

```
#(2022/05/03 13:45:16) CMD: XX XX XX XX XX XX XX XX XX XX
#(2022/05/03 13:45:30) CMD: XX XX XX XX XX XX XX XX XX XX
#(2022/05/03 13:45:41) CMD: XX XX XX XX XX XX XX XX XX XX
#(2022/05/03 13:45:49) CMD: XX XX XX XX XX XX XX XX XX XX
#(2022/05/03 13:45:57) CMD: XX XX XX XX XX XX XX XX XX XX
#(2022/05/03 13:46:05) CMD: XX XX XX XX XX XX XX XX XX XX
CO 00 4A 47 36 59 42 57 30 4A 47 36 59 40 58 30 3E FO FF FO F 00 00 01 C 00 00 00 00 00 00 00 00
CO 00 4A 47 36 59 42 57 30 4A 47 36 59 40 58 30 3E FO FF FO F 00 00 02 C 00 00 00 00 00 00 00 00
CO 00 4A 47 36 59 42 57 30 4A 47 36 59 40 58 30 3E FO FF FO F 00 00 03 C 00 00 00 00 00 00 00 00
CO 00 4A 47 36 59 42 57 30 4A 47 36 59 40 58 30 3E FO FF FO F 00 00 04 C 00 00 00 00 00 00 00 00
CO 00 4A 47 36 59 42 57 30 4A 47 36 59 40 58 30 3E FO FF FO F 00 00 05 C 00 00 00 00 00 00 00 00
CO 00 4A 47 36 59 42 57 30 4A 47 36 59 40 58 30 3E FO FF FO F 00 00 06 C 00 00 00 00 00 00 00 00
CO 00 4A 47 36 59 42 57 30 4A 47 36 59 40 58 30 3E FO FF FO F 00 00 07 C 00 00 00 00 00 00 00 00
CO 00 4A 47 36 59 42 57 30 4A 47 36 59 40 58 30 3E FO FF FO F 00 00 08 C 00 00 00 00 00 00 00 00
CO 00 4A 47 36 59 42 57 30 4A 47 36 59 40 58 30 3E FO FF FO F 00 00 09 C 00 00 00 00 00 00 00 00
CO 00 4A 47 36 59 42 57 30 4A 47 36 59 40 58 30 3E FO FF FO F 00 00 0A C 00 00 00 00 00 00 00 00
```

Commands

ACK or data

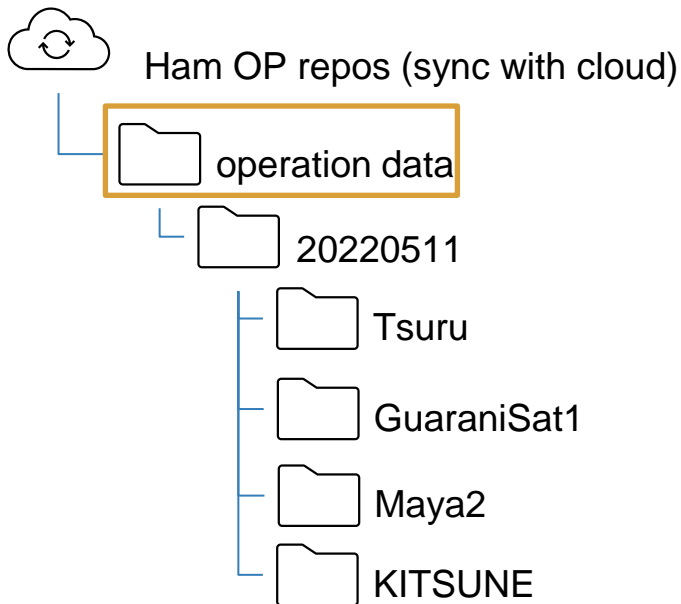
Seq. No.

Received packet(s) : 0

Received packets are shown in the software.

- Analyze (dropped)
  - Sequential number
  - to binary file
  - Finding missing

\*All data is saved in text file for open-source software.



## For multi-satellite operation

- A folder is automatically created for each satellite.
- Folder name refer freqList.csv
  - 7<sup>th</sup> column (G column)

freqList.csv

|    | A                         | B       | C         | D         | E         | F                | G           |
|----|---------------------------|---------|-----------|-----------|-----------|------------------|-------------|
| 1  | SatelliteName             | NoradID | CW beacn  | Uplink    | Downlink  | Remark           | Folder name |
| 2  | Norad(47927) Tsuru        | 47927   | 437375000 | 435xxxxxx | 437375000 | Norad            | Tsuru       |
| 3  | Norad(47929) Maya-2       | 47929   | 437375000 | 435xxxxxx | 437375000 | Norad            | Maya2       |
| 4  | Norad(47931) GuaraniSat-1 | 47931   | 437375000 | 435xxxxxx | 437375000 | Norad            | GuaraniSat1 |
| 5  | HORYU-IV                  | 41340   | 437375000 | 435xxxxxx | 437375000 | HORYU4           | HORYU4      |
| 6  | KOSEN-1                   | 99991   | 435525000 | 435xxxxxx |           | KOSEN-1          | KOSEN-1     |
| 7  | ISS                       | 25544   | 437375000 | 435xxxxxx | 437375000 | ISS              | ISS         |
| 8  | Norad(49273) Maya-3       | 49273   | 437375000 | 435xxxxxx | 437375000 | Deployed at 10/6 | Maya3       |
| 9  | Norad(49274) Maya-4       | 49274   | 437375000 | 435xxxxxx | 437375000 | Deployed at 10/6 | Maya4       |
| 10 | KITSUNE (NORAD)           | 52148   | 437375000 | 435xxxxxx | 437375000 | KITSUNE          | KITSUNE     |

# Frequency control -Supporting function-

## □ Doppler shift correction

- Calculating orbit from TLE
- Using OneSgp4 library
- Output to ICOM radio with CI-V protocol
- Update every 0.1sec

freqList.csv

|    | A                         | B       | C         |
|----|---------------------------|---------|-----------|
| 1  | SatelliteName             | NoradID | CW beacn  |
| 2  | Norad(47927) Tsuru        | 47927   | 437375000 |
| 3  | Norad(47929) Maya-2       | 47929   | 437375000 |
| 4  | Norad(47931) GuaraniSat-1 | 47931   | 437375000 |
| 5  | HORYU-IV                  | 41340   | 437375000 |
| 6  | KOSEN-1                   | 99991   | 435525000 |
| 7  | ISS                       | 25544   | 437375000 |
| 8  | Norad(49273) Maya-3       | 49273   | 437375000 |
| 9  | Norad(49274) Maya-4       | 49274   | 437375000 |
| 10 | KITSUNE (NORAD)           | 52148   | 437375000 |

tle.txt

```

0 ISS (ZARYA)
1 25544J 98067A 22132.35300373 .00005928 00000-0 11162-3 0 9992
2 25544 51.6429 154.0493 0006869 88.6298 34.7251 15.50035239339623
0 TSURU
1 47927U 980675D 22131.04782293 .00137611 00000-0 79184-3 0 9996
2 47927 51.6333 136.5953 0006455 44.9957 315.1565 15.77760239 65860
0 MAYA-2
1 47929U 980675F 22132.18823934 .00142389 00000-0 81518-3 0 9992
2 47929 51.6332 136.7140 0006269 51.7447 308.4117 15.77859573 66083
0 GUARANISAT-1
1 47931U 980675H 22132.17288133 .00148387 00000-0 83746-3 0 9991
2 47931 51.6318 136.6294 0006088 50.0009 310.1526 15.78148928 66842
0 HORYU-3
1 49273U 980675S 22132.14765912 .00101978 00000-0 83668-3 0 9992
2 49273 51.6343 143.9381 0004505 54.1797 305.9618 15.69648927 34801
0 MAYA-4
1 49274U 980675T 22132.16157975 .00100244 00000-0 83271-3 0 9992
2 49274 51.6348 144.8278 0004548 54.9673 305.1758 15.69358096 34800
0 KITSUNE
1 52148U 980677K 22132.17116032 .00019481 00000-0 31787-3 0 9993
2 52148 51.6427 154.4325 0003948 101.6814 335.8982 15.52589287 7601
    
```

## □ Fine tuning

- Follow tiny changes in frequency
- ±500Hz, ±1kHz, ±5kHz button

RX freq fine tuning

0 Hz

+500Hz

+1kHz

+5kHz

-500Hz

-1kHz

-5kHz



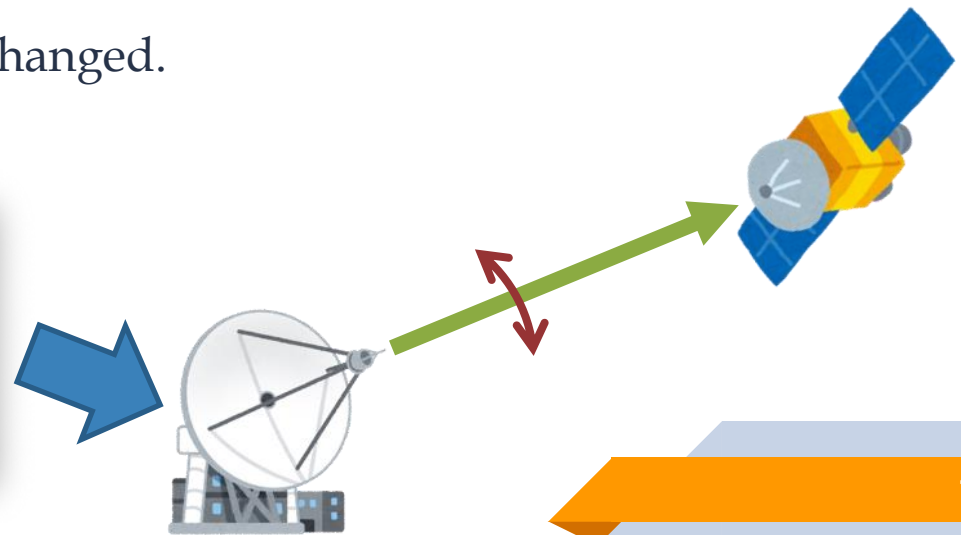
# Antenna Direction Control -Supporting function-

- ❑ Calculating orbit from TLE
- ❑ Output to the rotator by suitable protocol
- ❑ Update timing
  - Pro-Sis-Tel: Every 0.1 sec
  - YAESU: Command value is changed.

TLE

```

t1e.txt
0 ISS (ZARYA)
1 25544U 98067A 22132.35300373 .00005928 00000-0 11162-3 0 9992
2 25544 51.6429 154.0493 0006069 08.6298 34.7251 15.50035239339623
0 TSURU
1 47927U 980675D 22131.04702293 .00137611 00000-0 79104-3 0 9996
2 47927 51.6333 136.5953 0006455 44.9957 315.1565 15.77760239 65860
0 MAYA-2
1 47929U 980675F 22132.18823934 .00142389 00000-0 81518-3 0 9992
2 47929 51.6332 130.7140 0006269 51.7447 308.4117 15.77859573 66003
0 GUANANISAT-1
1 47931U 980675H 22132.17288133 .00148307 00000-0 83746-3 0 9991
2 47931 51.6310 130.6294 0006088 50.0009 310.1526 15.78148920 66042
0 MAYA-3
1 49273U 980675S 22132.14765912 .00101970 00000-0 83668-3 0 9992
2 49273 51.6343 143.9381 0004505 54.1797 305.9618 15.69648927 34001
0 MAYA-4
1 49274U 980675T 22132.16157975 .00100244 00000-0 83271-3 0 9992
2 49274 51.6340 144.8278 0004540 54.9673 305.1750 15.69358096 34000
0 KITSUNE
1 52148U 980677K 22132.17110832 .00013481 00000-0 31707-3 0 9993
2 52148 51.6427 154.4325 0003948 101.6814 335.0902 15.52589207 7601
  
```



- ❑ The history and how to do setting and operation are explained.
- ❑ Other ancillary software is necessary to operate efficiently.
  - CW decoder (DL from BIRDS-4 website)
  - Command generation software
  - Packet analyzer (converter to engineering value)
  - Missing packet check function
  - TLE updater



# BIRDS-4

JOINT GLOBAL MULTI-NATION BIRDS  
SATELLITE PROJECT



# Thank you!!!



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