Introduction of Open Platform Concept for Global Ground Station Network

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Japanese University activities

Japanese University activities

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Next stage for small satellite community

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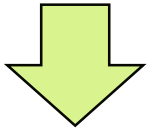
After satellite BUS technology development, after technology demonstration finished.

What do we do next?
How do we get research budget?
How can we create sustainable space application?



Most of next satellite mission require satellite constellation.
How do we operate 10s/100s satellites?

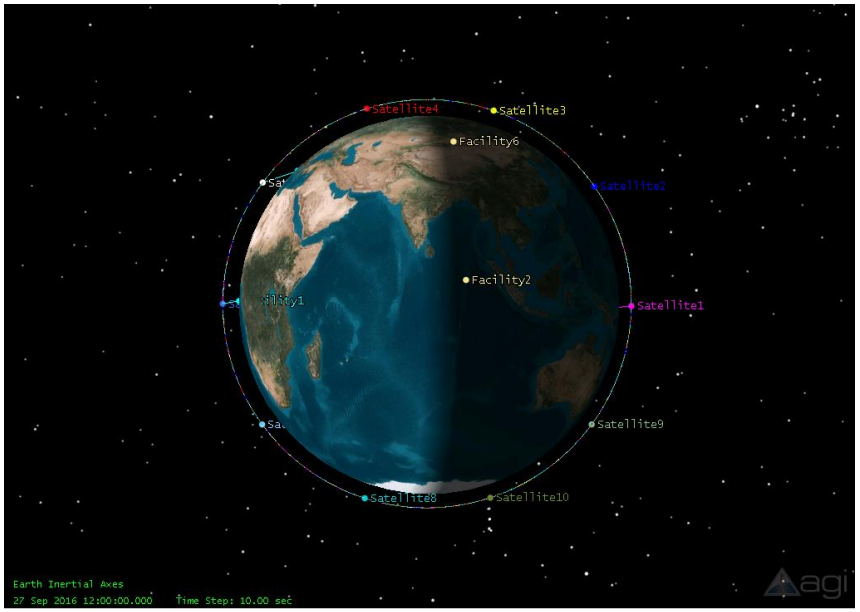
Contents

- Simple analysis of ground station number requirement
- Introduction of new satellite operation platform concept
- Conclusion

Analysis of Pass Overlap (1/2)

- Simplified analysis for Polar Earth Orbit and 10 satellites distributed one orbital surface (36 deg separation)
- Orbit and ground station parameters

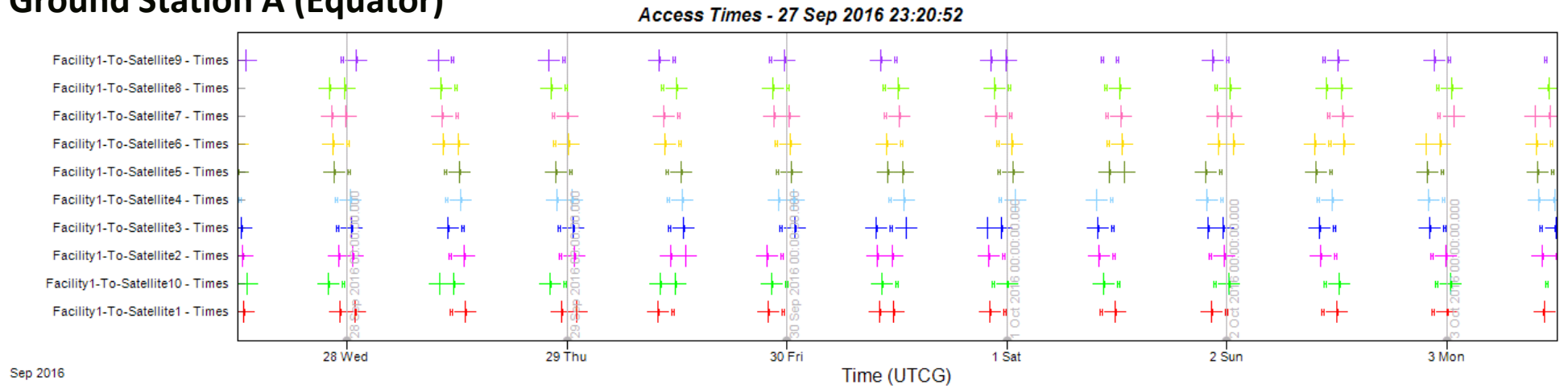
Orbit Parameter	Value
Apogee Altitude	600 km
Perigee Altitude	600 km
Inclination	98 deg
Argument of Perigee	0 deg
RAAN	0 deg



	Ground Station Location
Ground Station A	Latitude: 0 deg, Longitude: 0 deg Altitude Reference: WGS84
Ground Station B	Latitude: 45 deg, Longitude: 0 deg Altitude Reference: WGS84

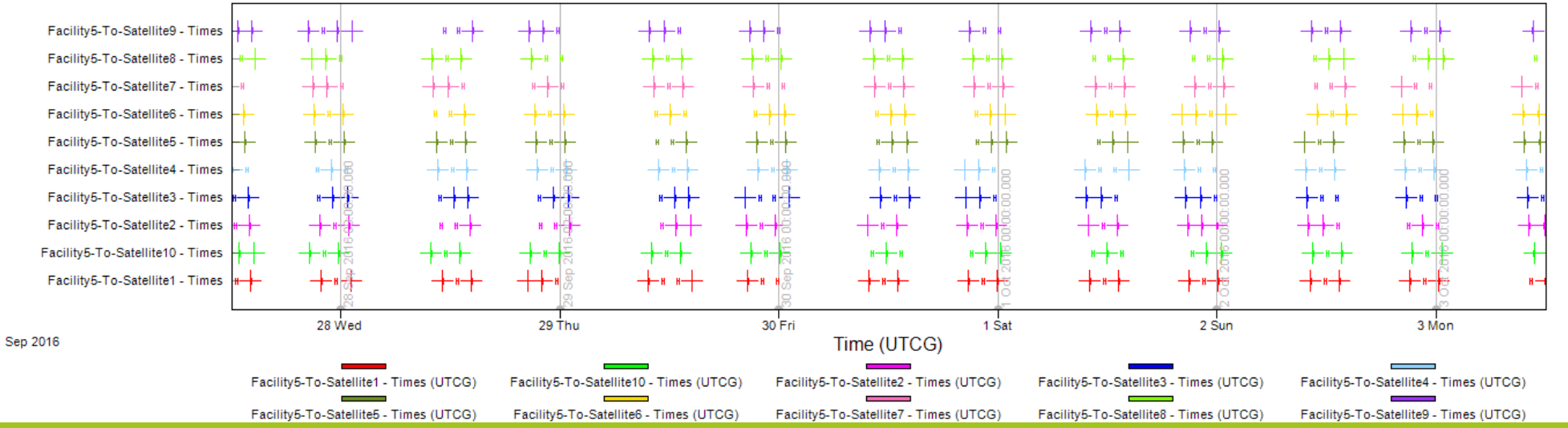
Analysis of Pass Overlap (2/2)

Ground Station A (Equator)



Passes are overlapped for satellites on same orbital surface

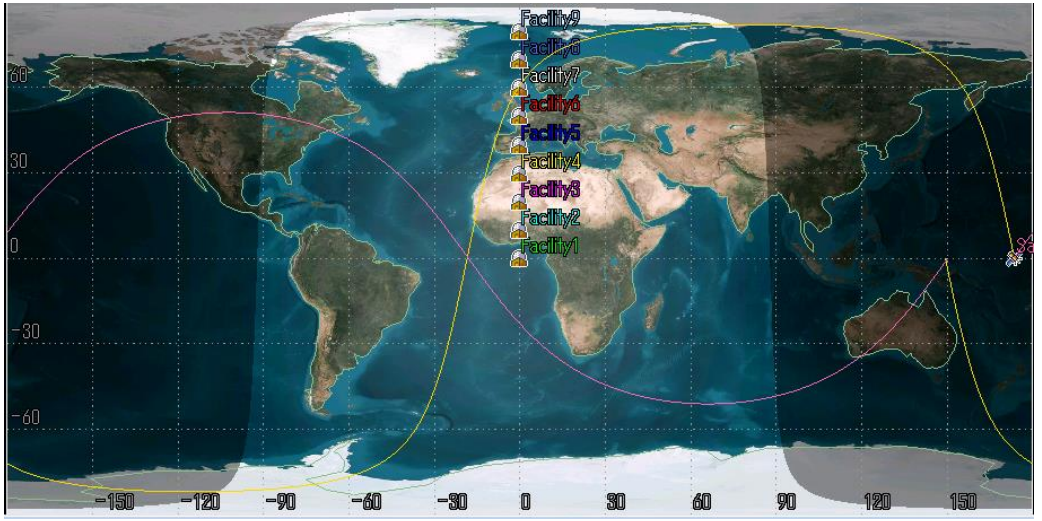
Ground Station B (Latitude 45 deg)



Analysis of Pass Duration (1/2)

- Simplified analysis for Polar Earth Orbit and ISS orbit
- Orbit and ground station parameters

Orbit Parameter	Value	
Apogee Altitude	600 km	400 km
Perigee Altitude	600 km	400 km
Inclination	98 deg	51 deg
Argument of Perigee	0 deg	0 deg
RAAN	0 deg	0 deg

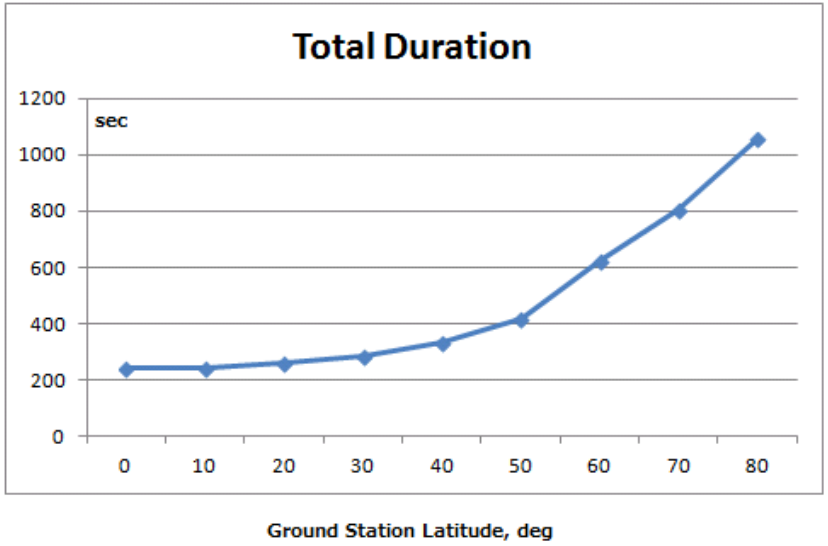


	Ground Station Location
Ground Station A – I	Latitude: 0, 10, 20, 30, 40, 50, 60, 70, 80deg Longitude: 0 deg Altitude Reference: WGS84

Analysis of Pass Duration (2/2)

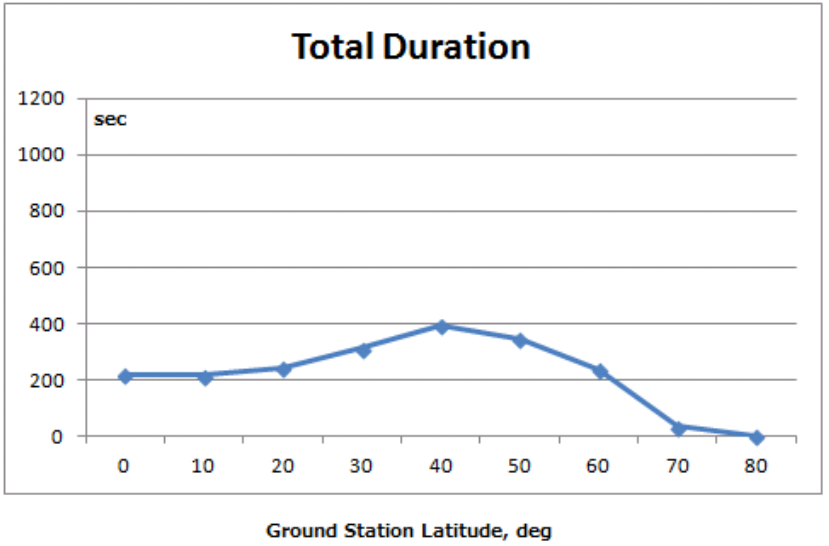
600km, 98 deg Inclination

Latitude (deg)	Number of Pass/Week	Total Pass Duration/Week (min)	Average Pass Duration/Day (min)
80	90	1056	150
70	74	807	115
60	64	625	89
50	42	417	59
40	33	331	47
30	29	286	40
20	26	262	37
10	24	245	35
0	24	240	34



400km, 51 deg Inclination

Latitude (deg)	Number of Pass/Week	Total Pass Duration/Week (min)	Average Pass Duration/Day (min)
80	0	0	0
70	12	34	4
60	30	234	33
50	36	344	49
40	42	391	55
30	39	312	44
20	29	242	34
10	25	215	30
0	27	216	30



Ground Station Number Requirement

The number of required ground station for a given constellation is roughly estimated based on the above discussion.

$N_{max} \times T_{op} = N_{lat1} \times T_{GS1} + N_{lat2} \times T_{GS2} + \ldots + N_{latn} \times T_{GSn}$

- Maximum number of satellites in an orbital plane, N_{max}
- Required pass duration per day for operation, T_{op}
- Number of ground stations at n degree latitude, N_{latn}
- Average pass duration for ground stations at n degree latitude, T_{GSn}

Number of required ground station:

$N_R = N_{lat1} + N_{lat2} + \ldots + N_{latn}$

Problems

- There is high possibility of pass overlap for constellation operation.

- Non-constellation operation

Number of ground station Total communication duration

linear

- For constellation

Number of ground station Total communication duration

Not linear

Ground System Cost (CAPEX/OPEX)

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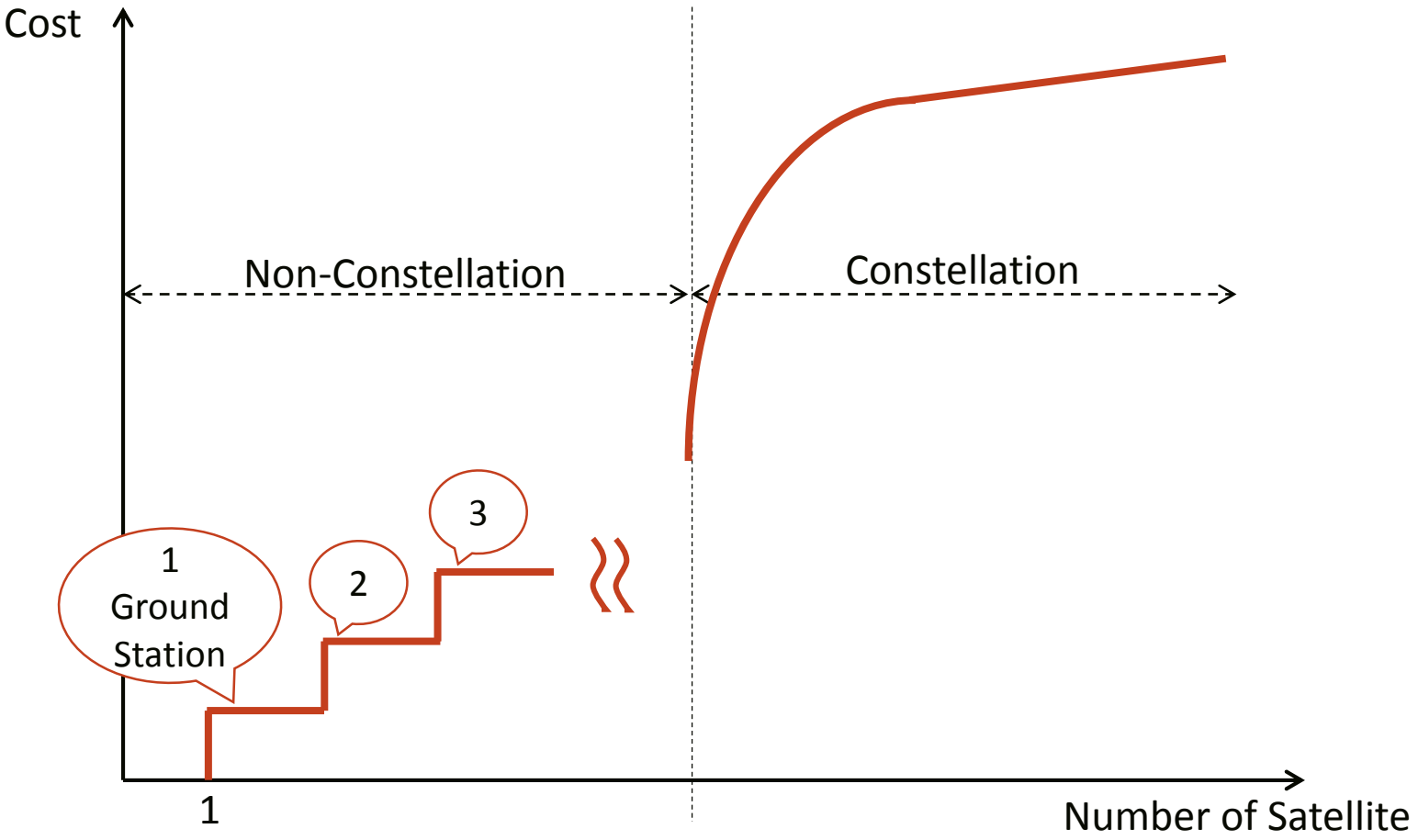
Ground system cost doesn't increase linearly.



Satellite Pass Cost

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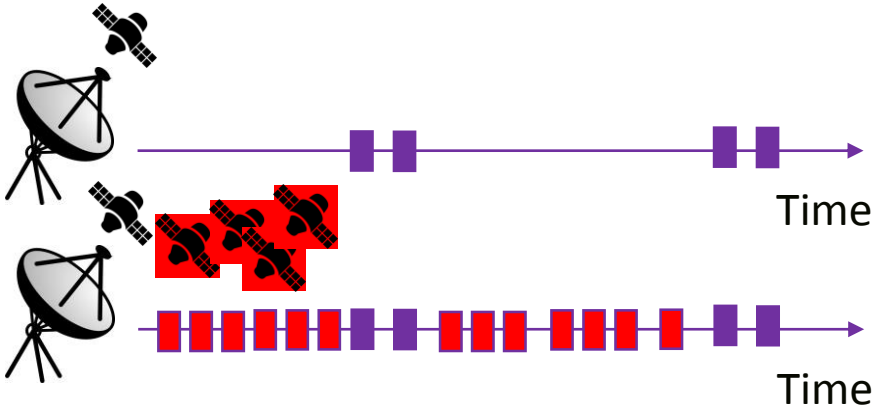
Type	Initial Cost, USD	Power+Internet Cost/month, USD	Initial + Running Cost/5 years, USD	Pass/day	Pass/5 years	Cost/pass, USD
Yagi	10,000	600	10,000 + 36,000 = 46,000	5	9125	5 <
		600	10,000 + 36,000 = 46,000	12	21,900	2 <
		2,000	10,000 + 120,000 = 130,000	60	109500	1 <
Dish (2 – 4 m)	400,000 (200,000 – 600,000)	600	400,000 + 36,000 = 436,000	5	9125	48 <
		600	400,000 + 36,000 = 436,000	12	21,900	20 <
		2,000	400,000 + 120,000 = 520,000	60	109500	5 <

Antenna usage increased, satellite pass cost decreased.

Satellite Operation Platform for Constellation

- Need ground station network as infrastructure, such as the Internet.
- How to create? ⇒ Apply “Sharing Economy” concept



- How to be a sustainable network?

⇒ Charge for private business. (Running cost)

⇒ Return free/cheap pass usage for contributor, who share their antenna’s idling time. (Network growth)

Summary

- Infrastructure of satellite operation is needed to realize next satellite constellation application

- Antenna sharing-economy system for satellite operation is proposed to create the infrastructure.

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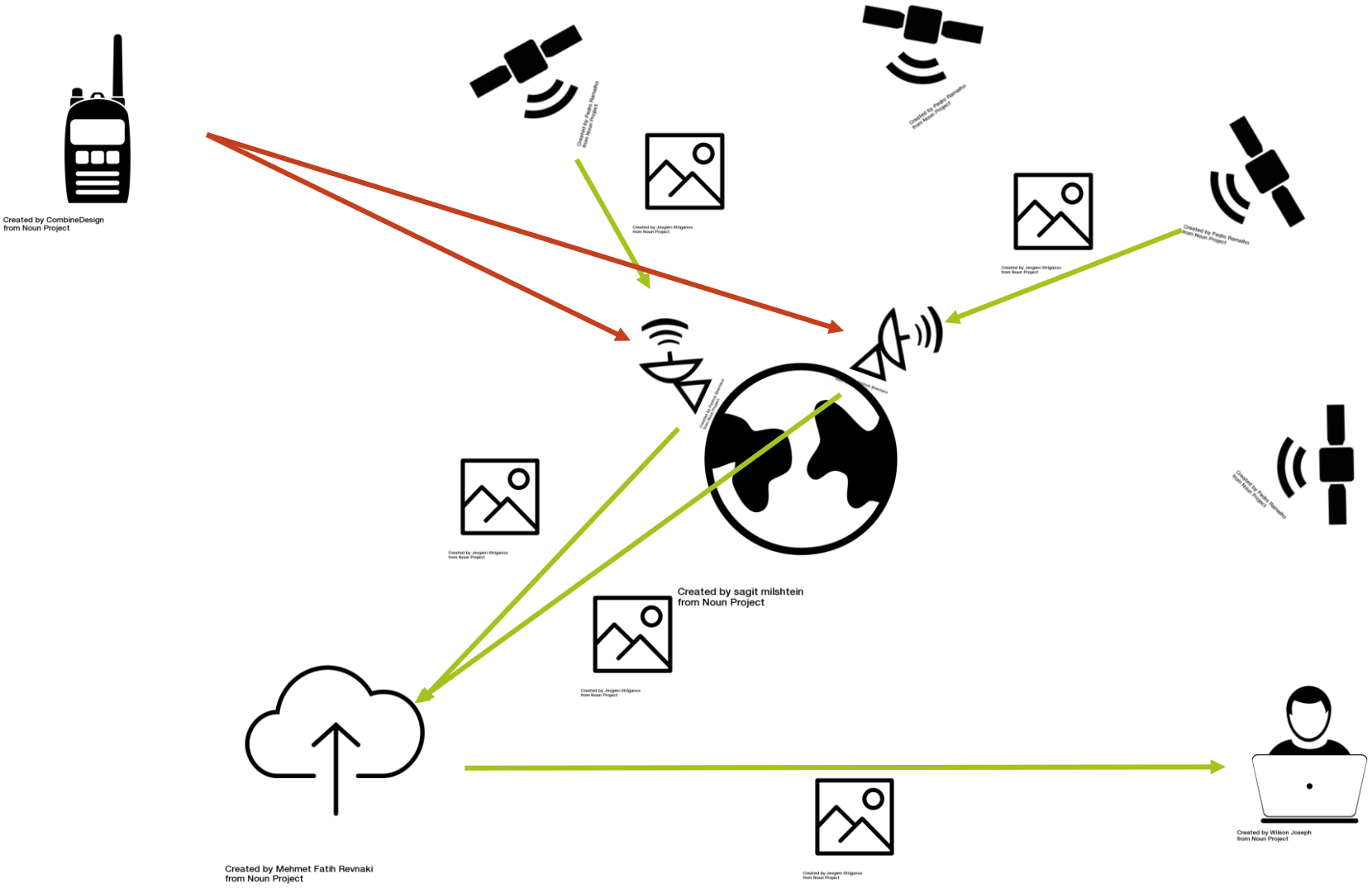

Provide connections between antenna-cround server-satellite operator

22nd October, 2016
Group Discussion Session

Group 5:
Collaborators meeting for new ground station network experiment

Thank you.

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