

# NEW SPACE OPERATIONS IN THE INTERNET OF THINGS ERA - ANYWHERE, ANYTIME, ANYTHING!

*IAC2016, Guadalajara, Small Sat Operations (B4.3)*

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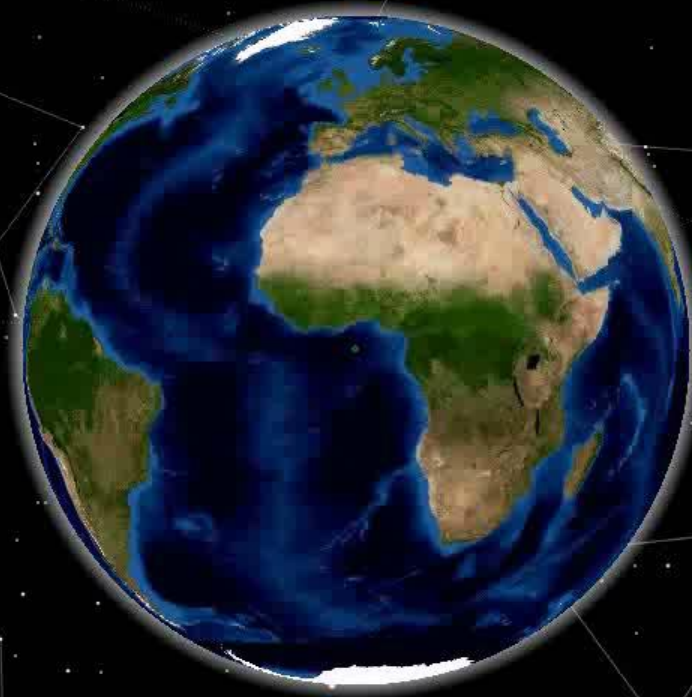
what is this?

**Saudi-OSCAR 50?**

- 2002-058C
- 436.800 MHz

In 2013 the Global Standards Initiative on Internet of Things (IoT-GSI) defined the IoT as  
***"the infrastructure of the information society".***

ITU, Internet of Things Global Standards Initiative (Geneva)



According to estimations for 2020, IoT will consist  
***"of almost 50 billion objects and interconnection is expected  
to usher in automation in nearly all fields".***

Dave Evans, Cisco "The Internet of Things," April 2011.





# Why?

Some CubeSats  
Lost in Space! ;)  
But not for long

*"Today: NanoRacks Inadvertent Deploy:  
**On Saturday, ground teams  
observed the inadvertent deploy**  
of two Cosmogia CubeSats from Deployer #5  
of the NanoRack Cubesat Deployer (NRCSD).*

September 5, 2014

[nasawatch.com/archives/2014/09/problems-persis.html](http://nasawatch.com/archives/2014/09/problems-persis.html)



# AntennaForest above Stuttgart

2.4GHz wifi  
intended for Freifunk

70cm-band yagi  
for DGSN

2m-band turnstile  
for DGSN

2m-band yagi  
for ham-radio  
and DGSN

your  
place

**S21**

North

South-East

to Stuttgart  
makerspace  
shackspace

a DGSN  
node station  
in **makerspace**



# What else can you do?

*hacker prepares  
satellite port scan*

**Travis Goodspeed**  
US-Navy Inmarsat Dish

# Many more things!

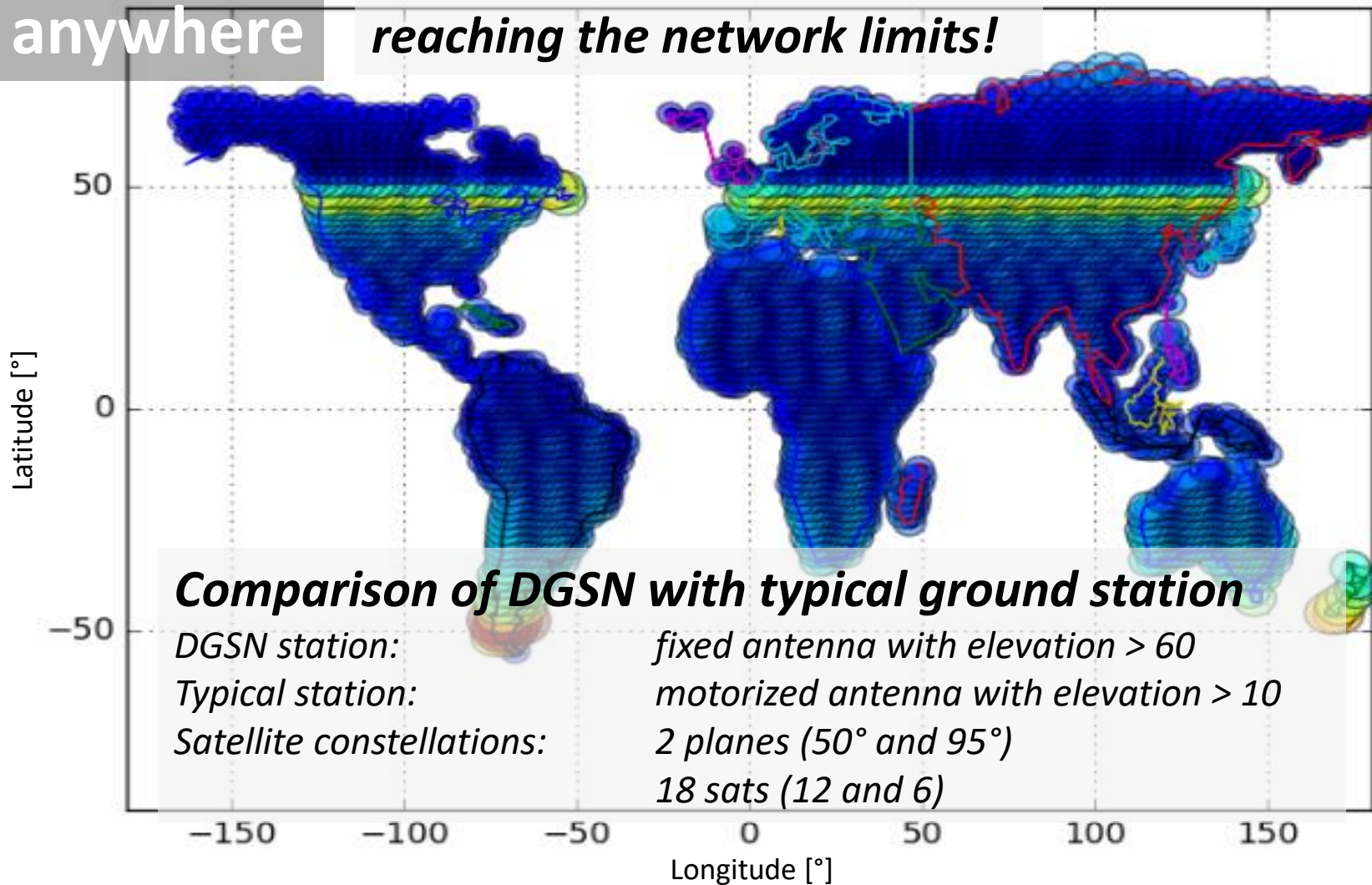
please stay & ask  
LeafSpace B4.3.2  
Helen/Ukube-1 B4.3.1  
during their talks ;)

*hobbyists re-activate  
NASA satellite*

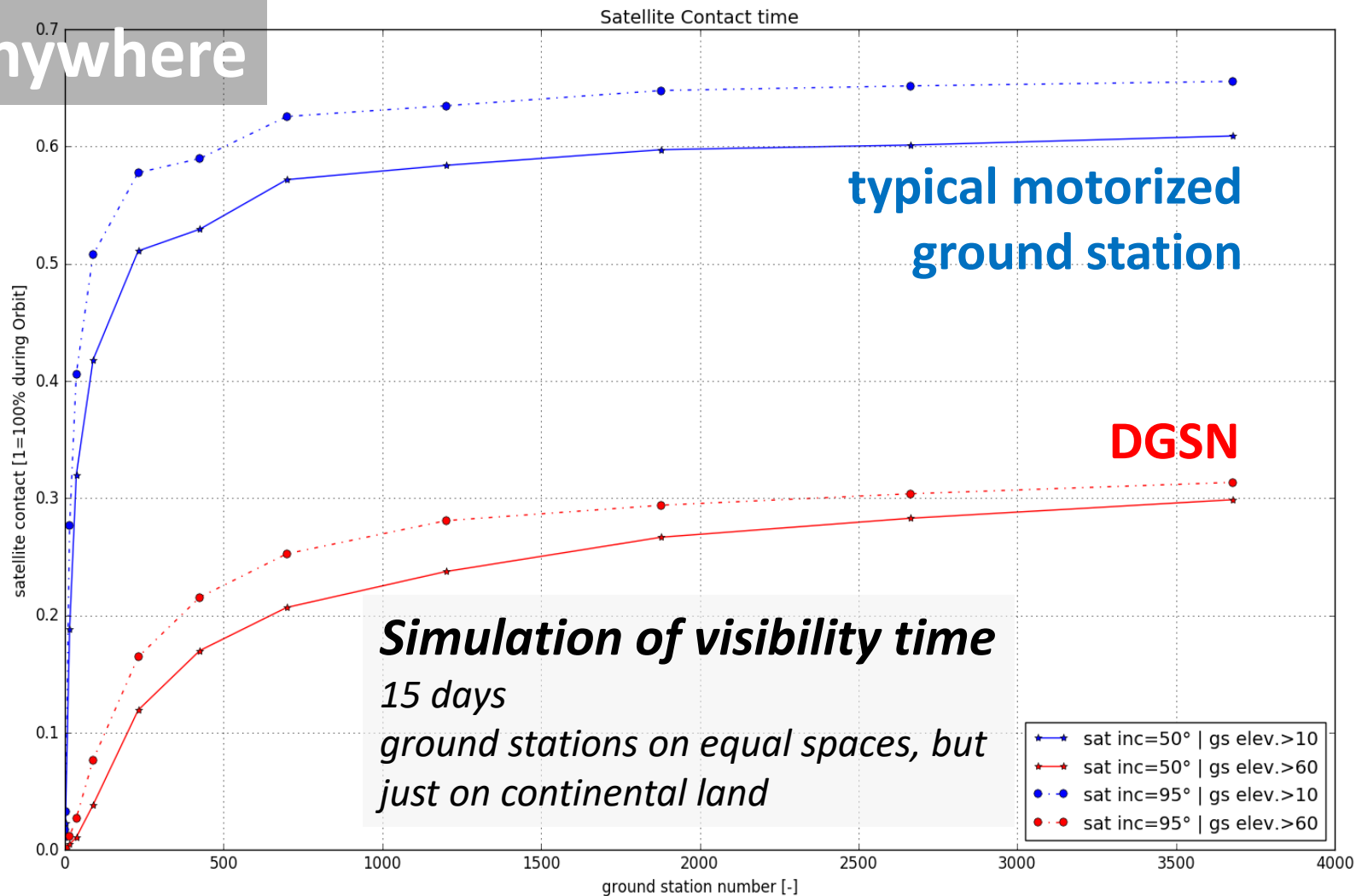
**ISEE-3 Reboot**  
Stanford Dish

anywhere

*reaching the network limits!*

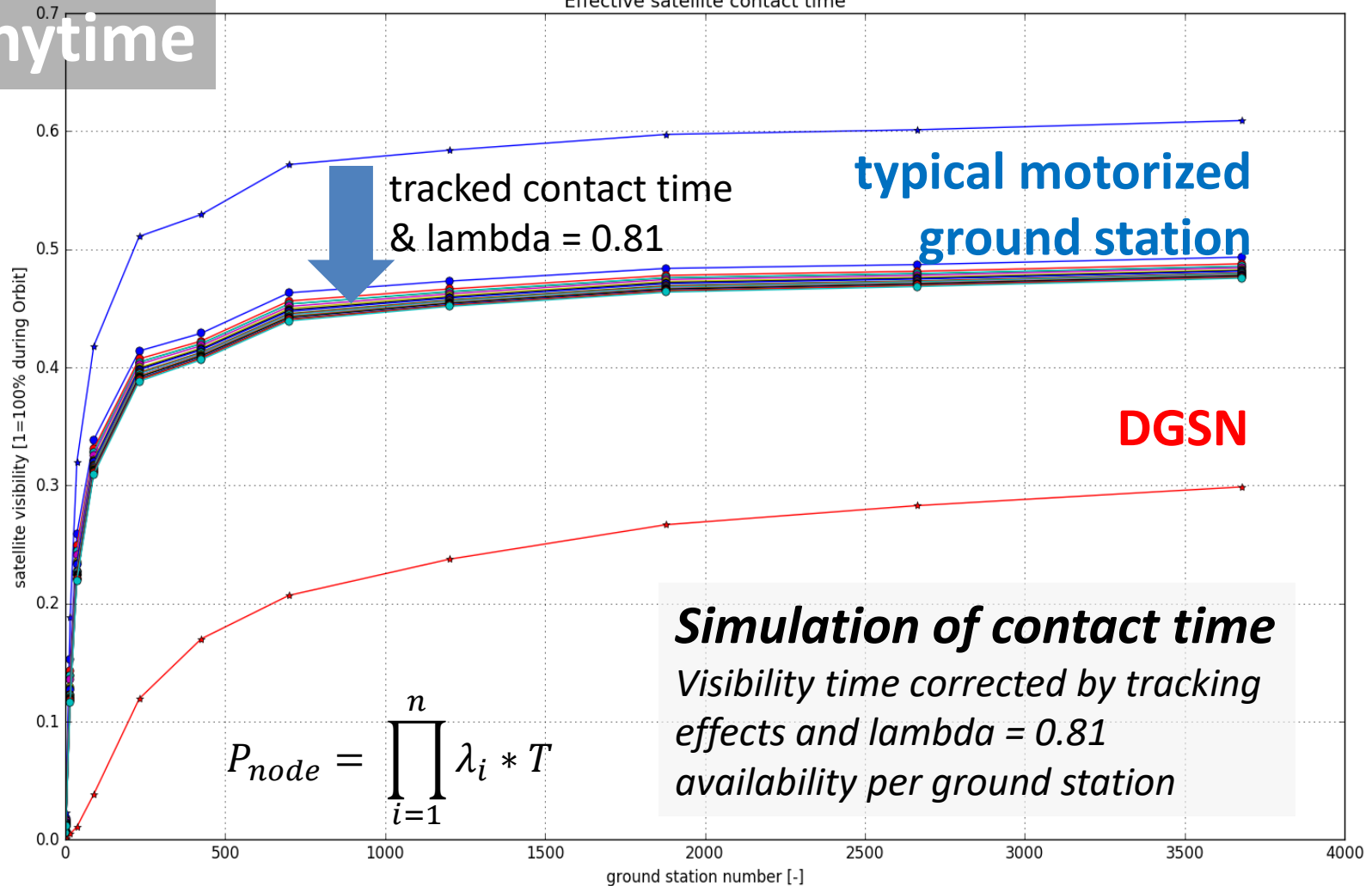


anywhere



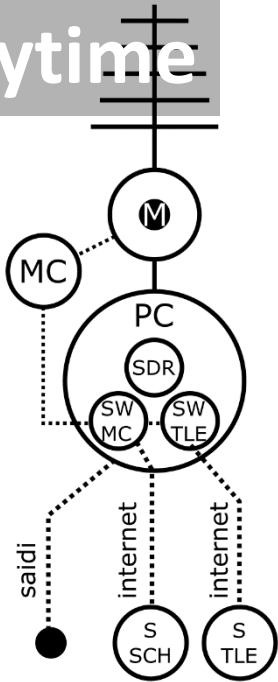
Effective satellite contact time

anytime

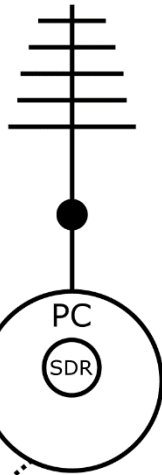




anytime



steerable antenna



fixed antenna

Don't forget,  
**complex  
systems  
break, too!**

$$P_{node} = \prod_{i=1}^n \lambda_i * T$$

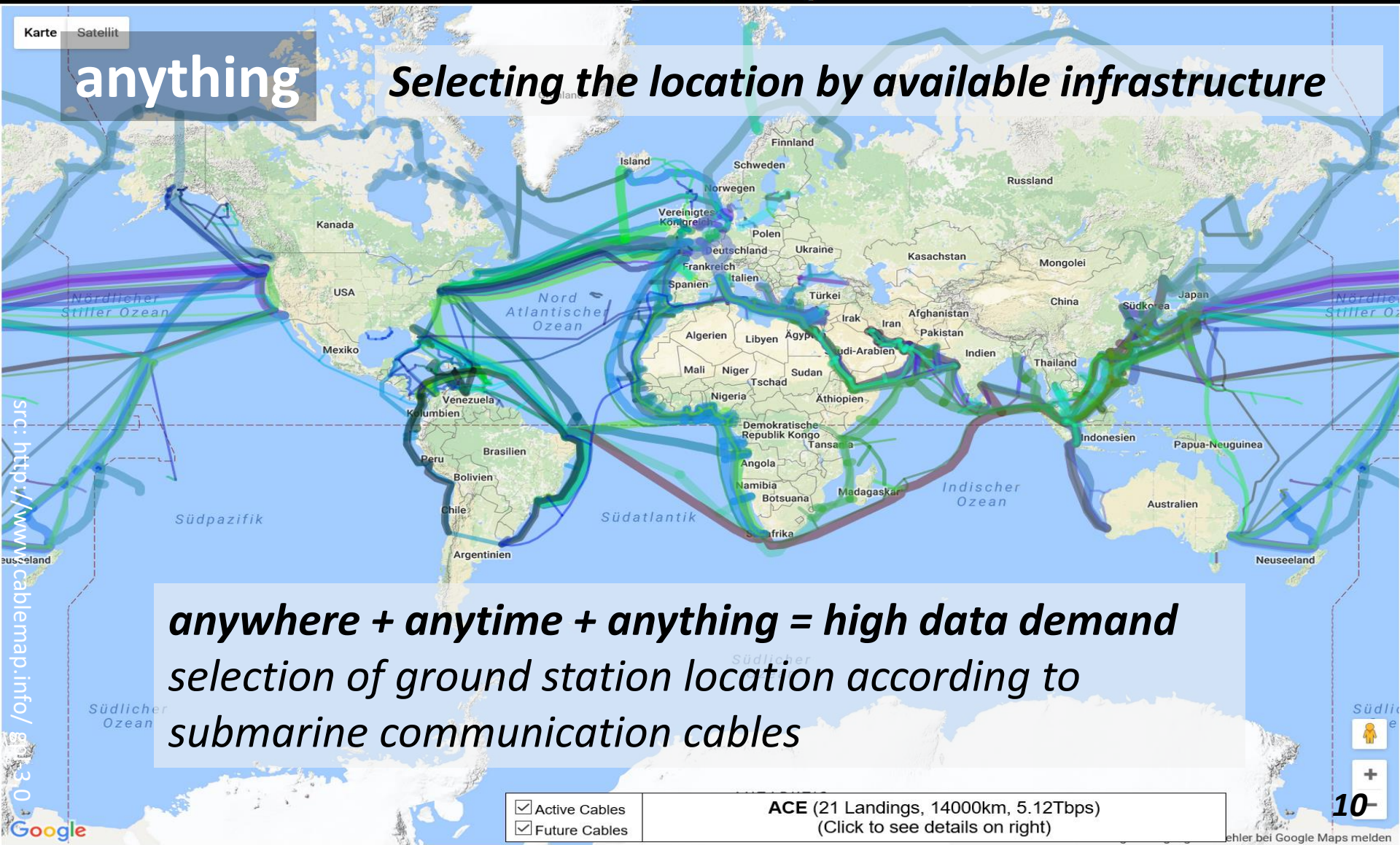
	Ground Station Components	$\lambda$ for components of Ground Station w/ steerable antenna (elevation > 10°)	$\lambda$ for components of Ground Station w/ fixed antenna (elevation > 60°)
satellite	Computer including...	0.97011	0.98981
	-SAIDI [13] (EU average)	0.99981	0.99981
	-SW SDR	0.99	0.99
	-SW Motor-Control	0.99	-
	-SW TLE Scheduler	0.99	-
	Antenna including...	0.94411	-
	-Motor	0.95	-
	-Microcontroller	0.9938	-
	TLE Server	0.97	-
	Internet [14] to TLE	0.97	-
	Scheduler Server	0.97	-
	Internet [14] to Scheduler	0.97	-
	Total System	0.81083	0.98981

Table 1: Title of table, left justified, subsequent text indented. Heading centred. Do not use vertical lines within the table; use horizontal lines only to separate headings from table entries

Karte Satellit

**anything**

**Selecting the location by available infrastructure**

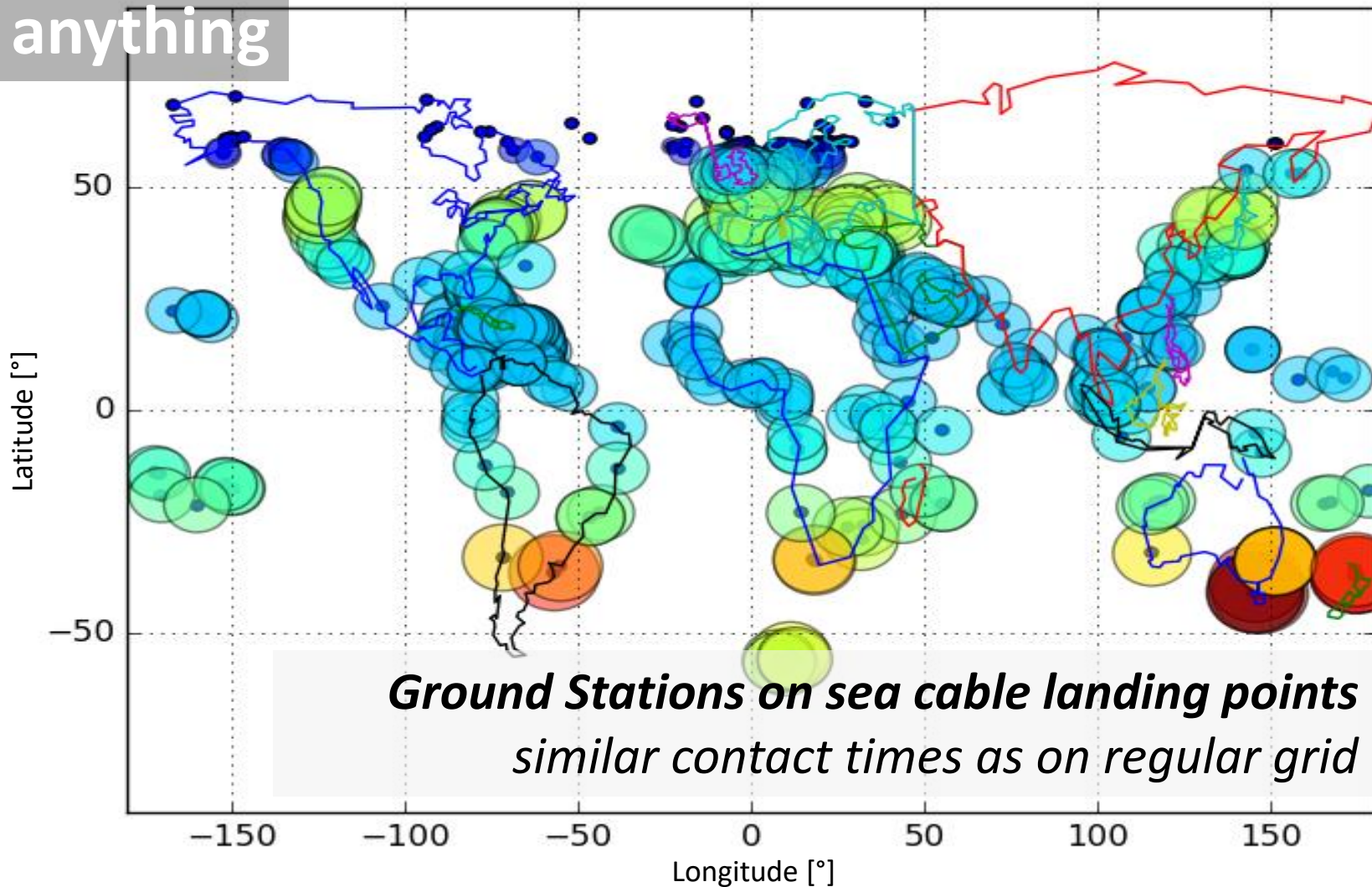


**anywhere + anytime + anything = high data demand**  
**selection of ground station location according to**  
**submarine communication cables**

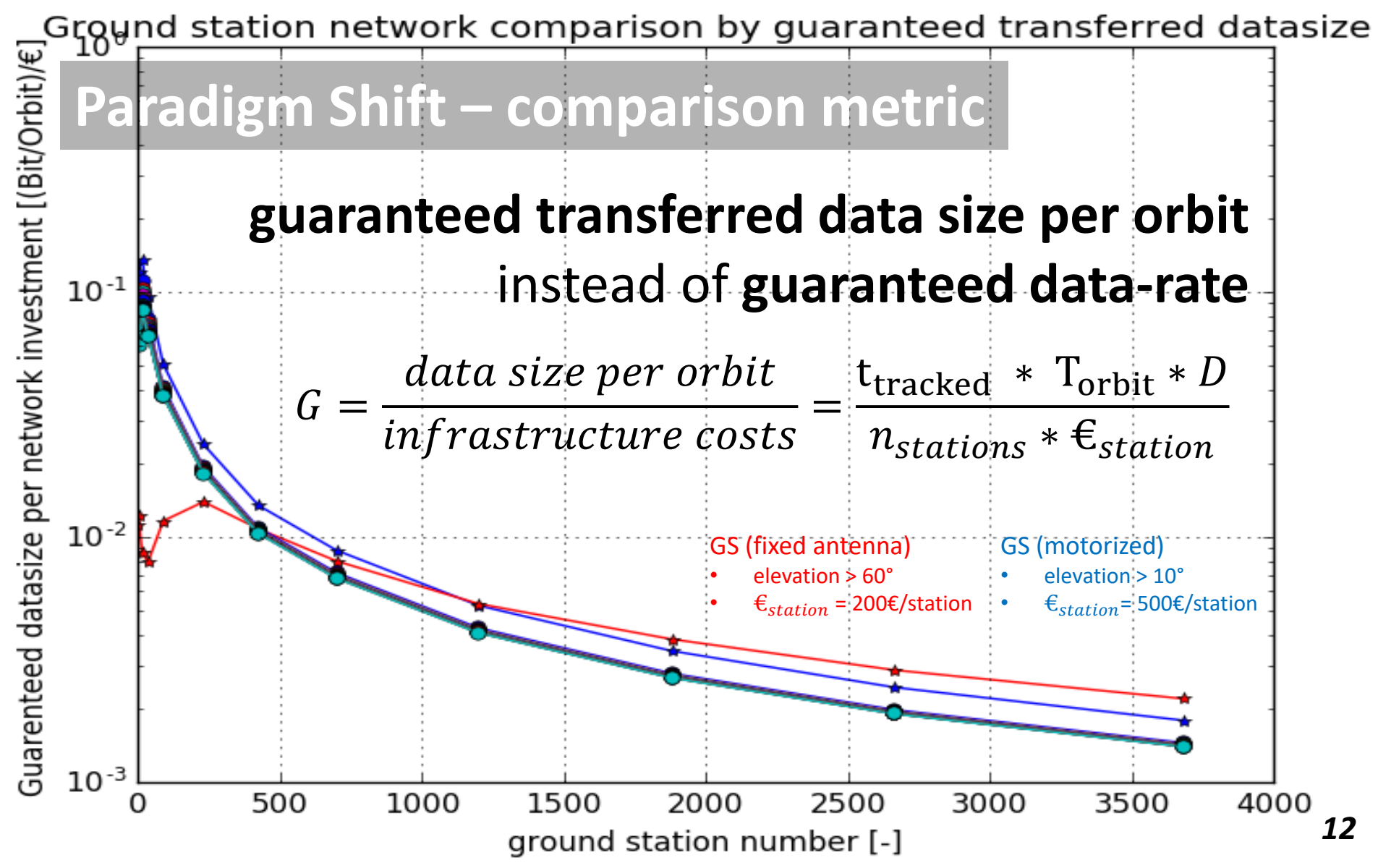
- ☒ Active Cables
- ☒ Future Cables

**ACE** (21 Landings, 14000km, 5.12Tbps)  
 (Click to see details on right)

anything







# Paradigm Shift – design criteria

## Scalability

- performance of nodes & backend
- reliability and maintenance

=> INVESTMENT

## Location

- mission requirement
- local infrastructure (internet, power)

=> INFRASTRUCTURE

## Paradigm Shift – advantages

*IoT opens a new  
direct and indirect roadmap*

for space ops...

1. big data & more open (source) data
2. standardized & open (source) interfaces
3. open (source) hardware and software
4. standardization committee and new open communities
5. open space segment eco-system



## Paradigm Shift – trust and/or security

*a global grid with accesable nodes  
requires mutual trust!*

**multiple sources of error and attack vectors...**

- manipulation of data on the node
- manipulation of location
- manipulation of availability
- manipulation of hardware and
- manipulation of command and control (if transmission is required)

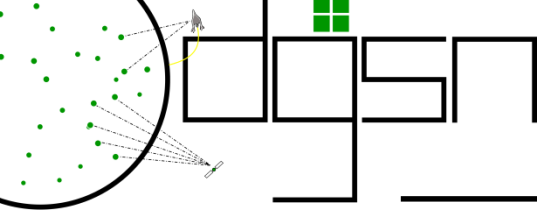
# Conclusion

## **Internet of Things era is there!**

- *will be / is already the infrastructure of space ops*
- *offers advantages in automation especially for mega constellations like OneWeb and SpaceX*
- *offers new tools and cooperations for small organizations*
- *raises demand for new security approaches*
- *raises demand in infrastructure*

## **Distributed Ground Station Network (DGSN)**

- *IoT is the only way for scalability*
- *comparison metric supports “island” deployment approach (core network of clustered stations + open for external users)*
- *open-source approach supports mutual trust*
- *cooperative design and operation*
- *measuring everything!* Transmission at a later phase



distributed ground station network

17/

want to join a global internet-connected satellite tracking grid  
or are you in need to find you missing CubeSat?

## Distributed Ground Station Network

CreativeCommons BY-NC-SA applies

Thank you for your attention!

**hornig@aerospaceresearch.net**  
**code on [github.com/aerospaceresearch](https://github.com/aerospaceresearch)**



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Germany



*FairUse  
applies  
on logos  
and fotos  
with  
sources!*