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

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

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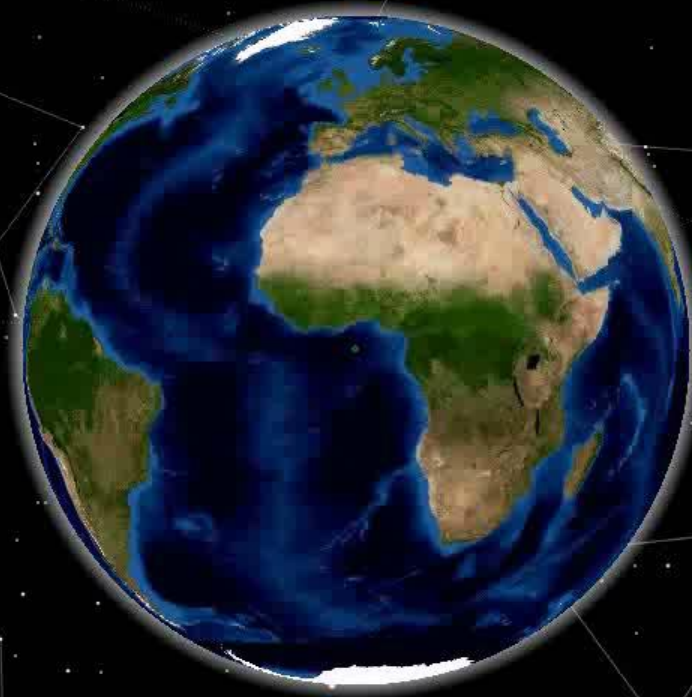
Prof. Dieter FRITSCH
IFP, University of Stuttgart

what is this?

Saudi-OSCAR 50?
- 2002-058C
- 436.800 MHz

2016-09-27 | IAC-16-B4.3.2-x33536

1

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 <u>inadvertent</u> 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

3

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

North

S21

South-East

to Stuttgart
makerspace
shackspace

a DGSN
node station
in **makerspace**

4

What else can you do?

hacker prepares
satellite port scan

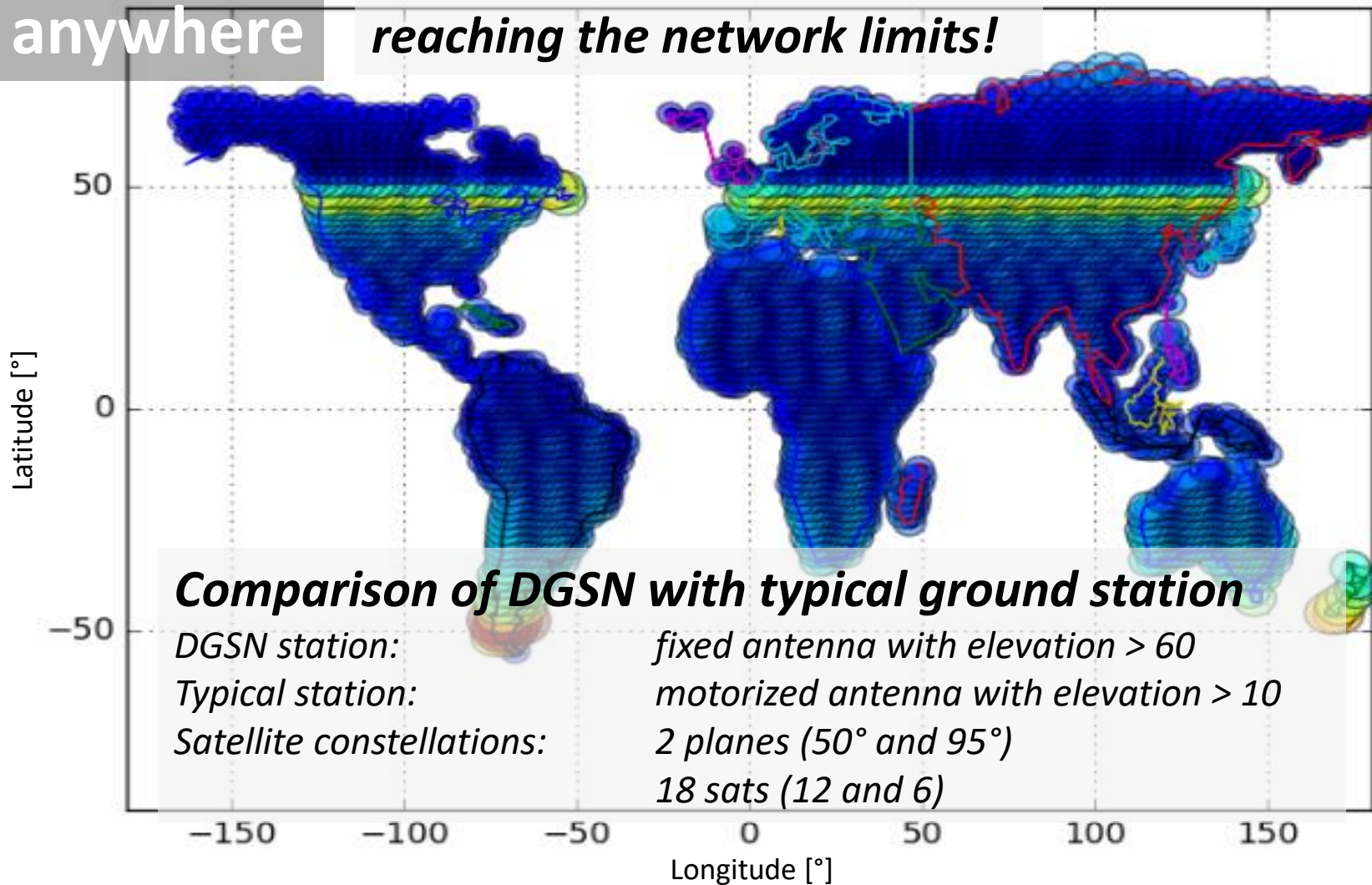**Travis Goodspeed**
US-Navy Inmarsat Dish

Many more things!

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

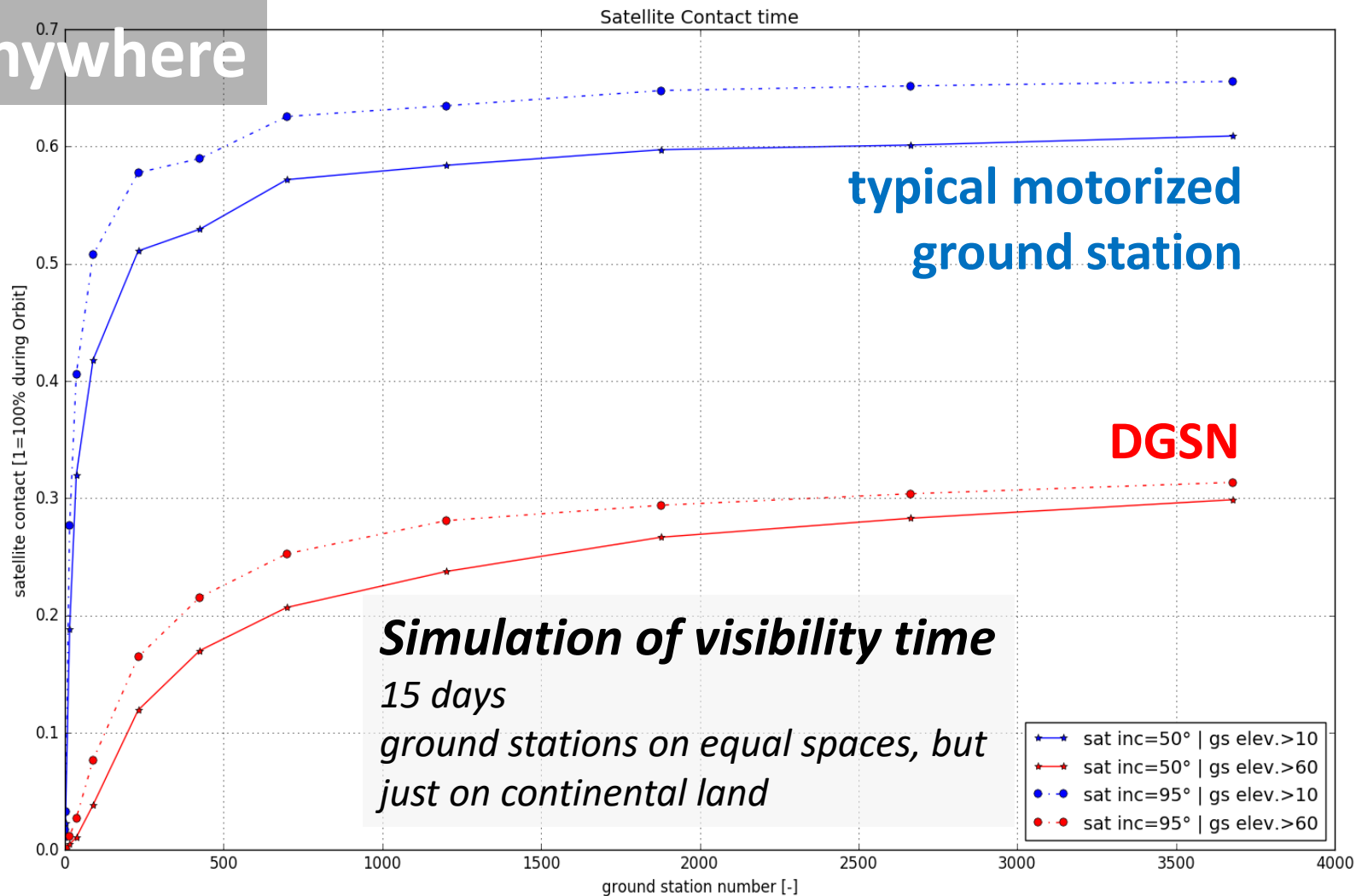*hobbyists re-activate*
NASA satellite

ISEE-3 Reboot
Stanford Dish

anywhere *reaching the network limits!*

Comparison of DGSN with typical ground station

DGSN station:	*fixed antenna with elevation > 60*
Typical station:	*motorized antenna with elevation > 10*
Satellite constellations:	*2 planes (50° and 95°)*
	18 sats (12 and 6)

Latitude [°]

Longitude [°]

Effective satellite contact time

satellite visibility [1=100% during Orbit]

ground station number [-]

tracked contact time & lambda = 0.81

typical motorized ground station

DGSN

Simulation of contact time
Visibility time corrected by tracking effects and lambda = 0.81 availability per ground station

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

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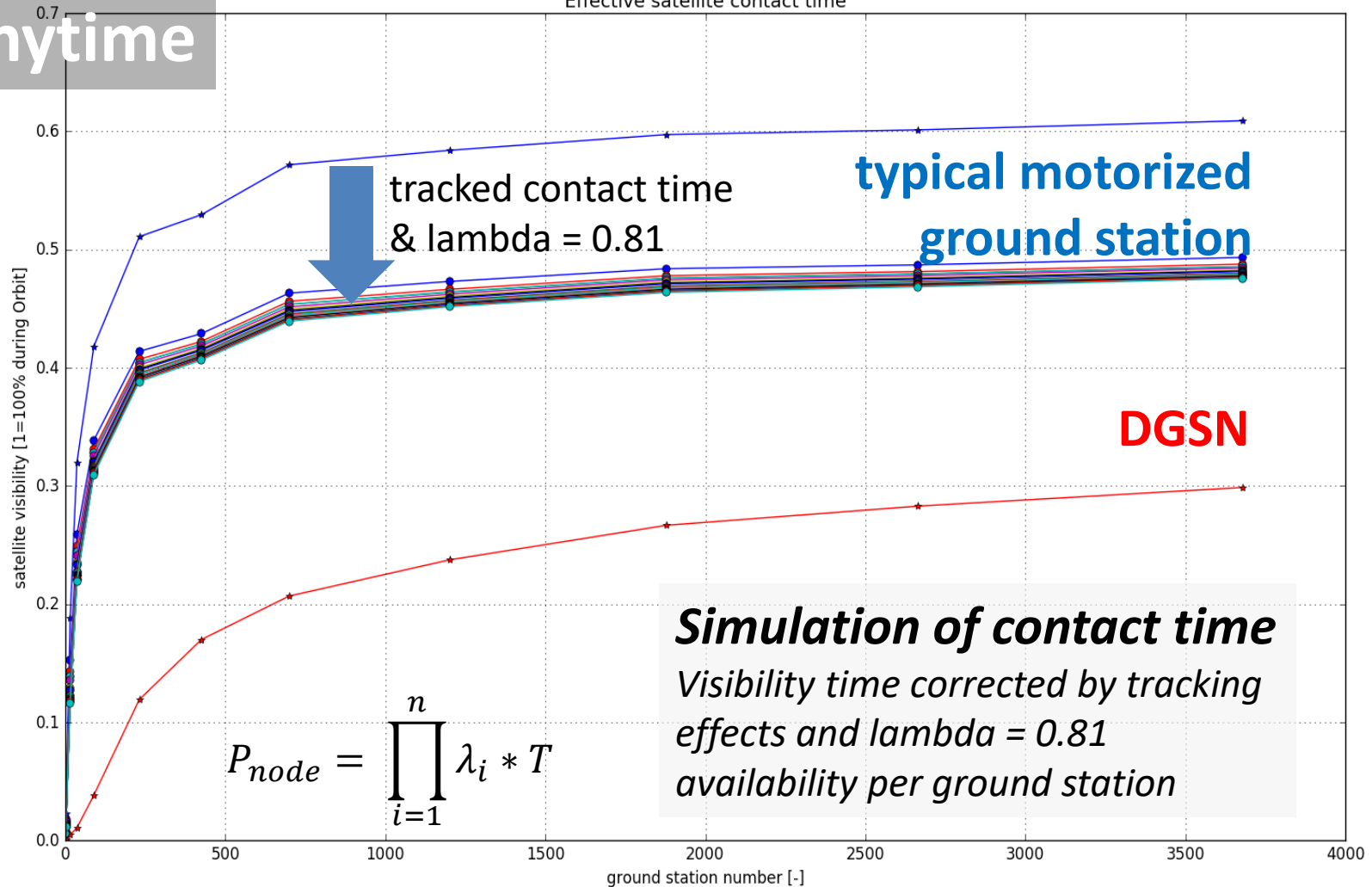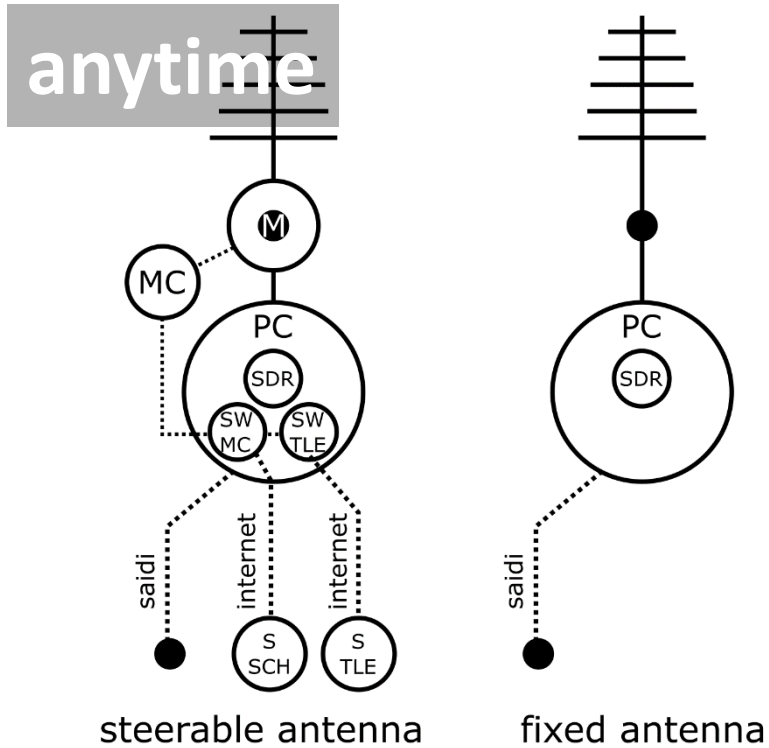
Don't forget, **complex systems break, too!**

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

Ground Station Components	λ for components of Ground Station w/ steerable antenna (elevation > 10°)	λ for components of Ground Station w/ fixed antenna (elevation > 60°)
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
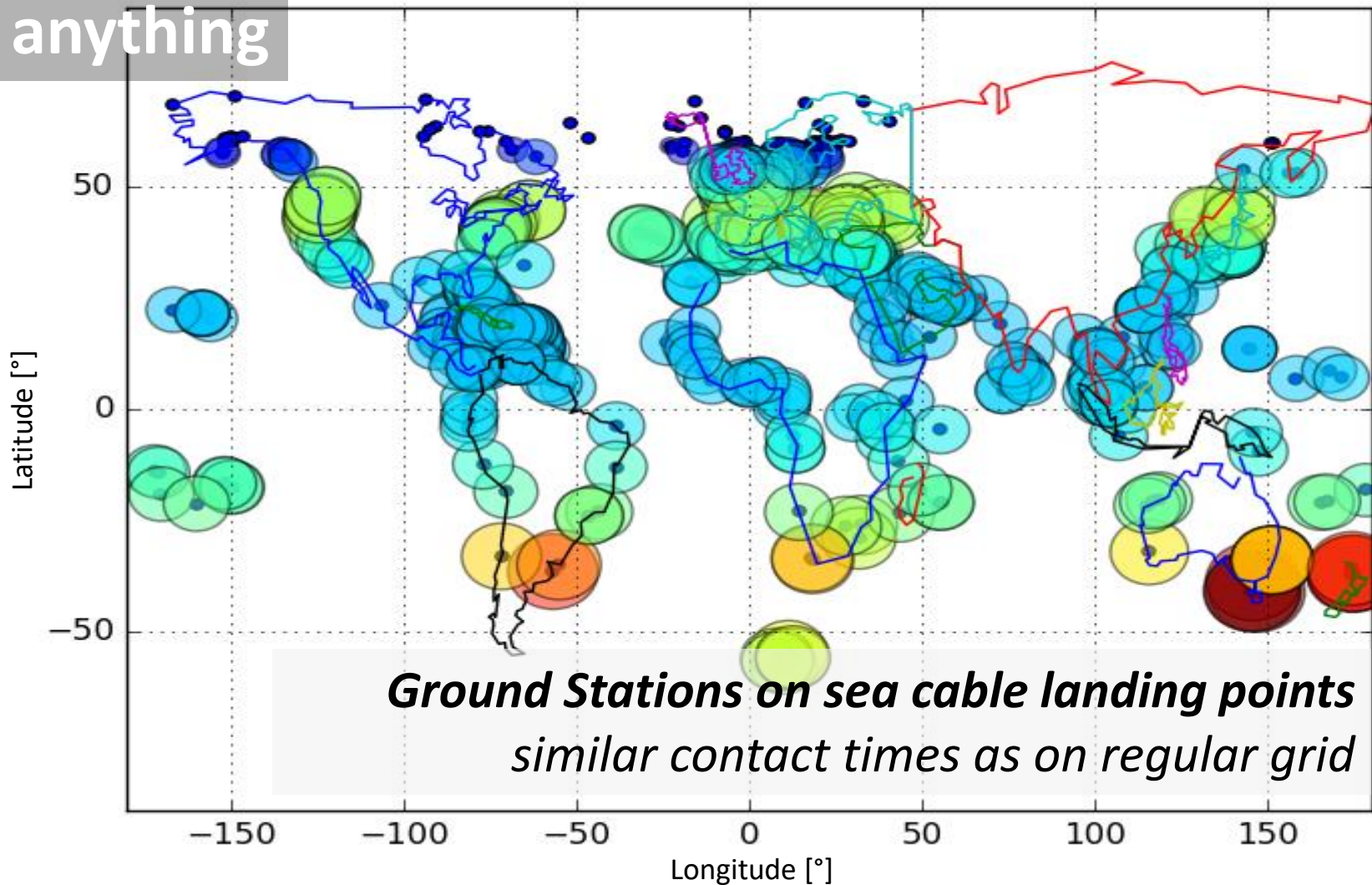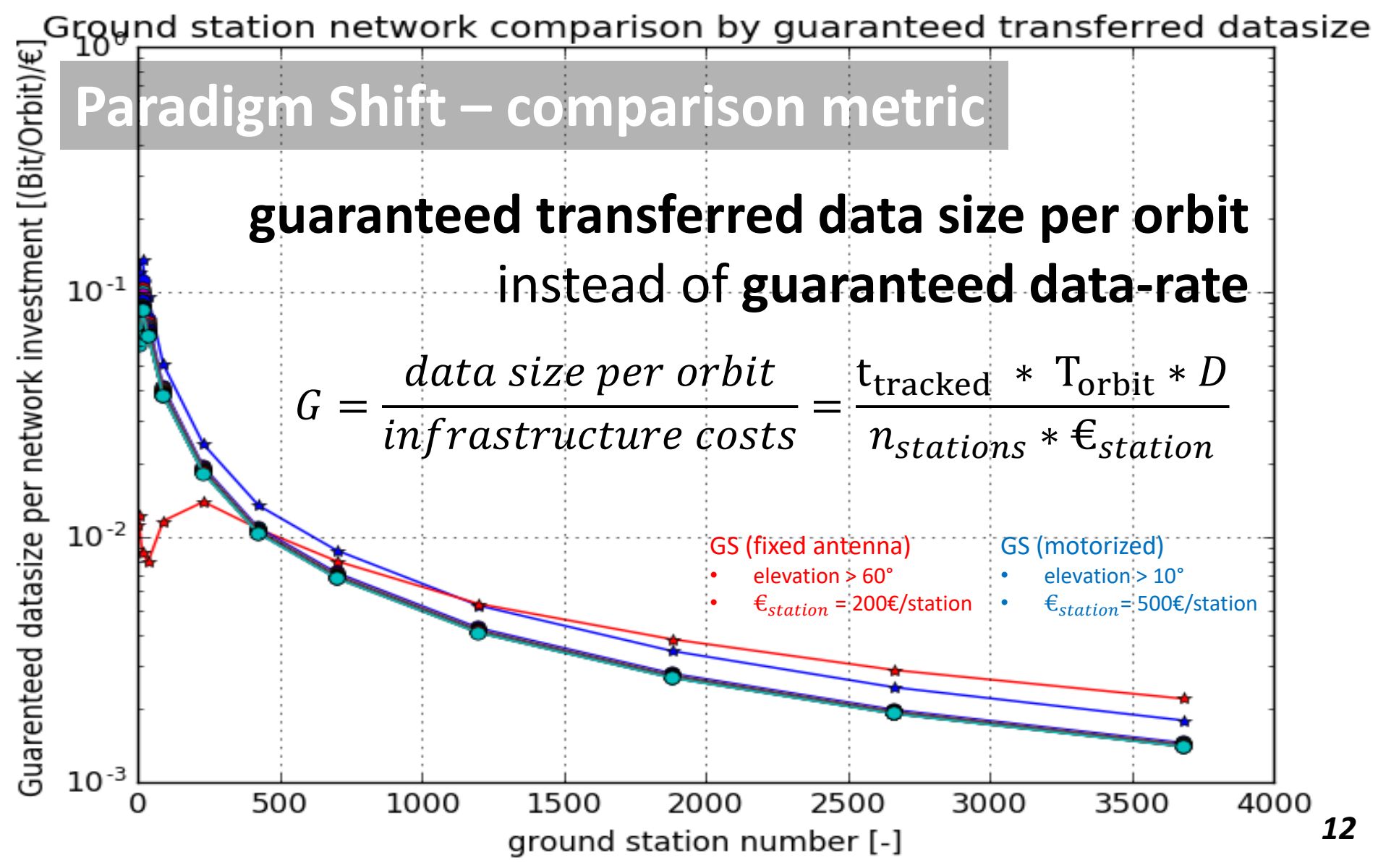
Karte Satellit

anything   *Selecting the location by available infrastructure*

src: http://www.cablemap.info/ @ 3.0
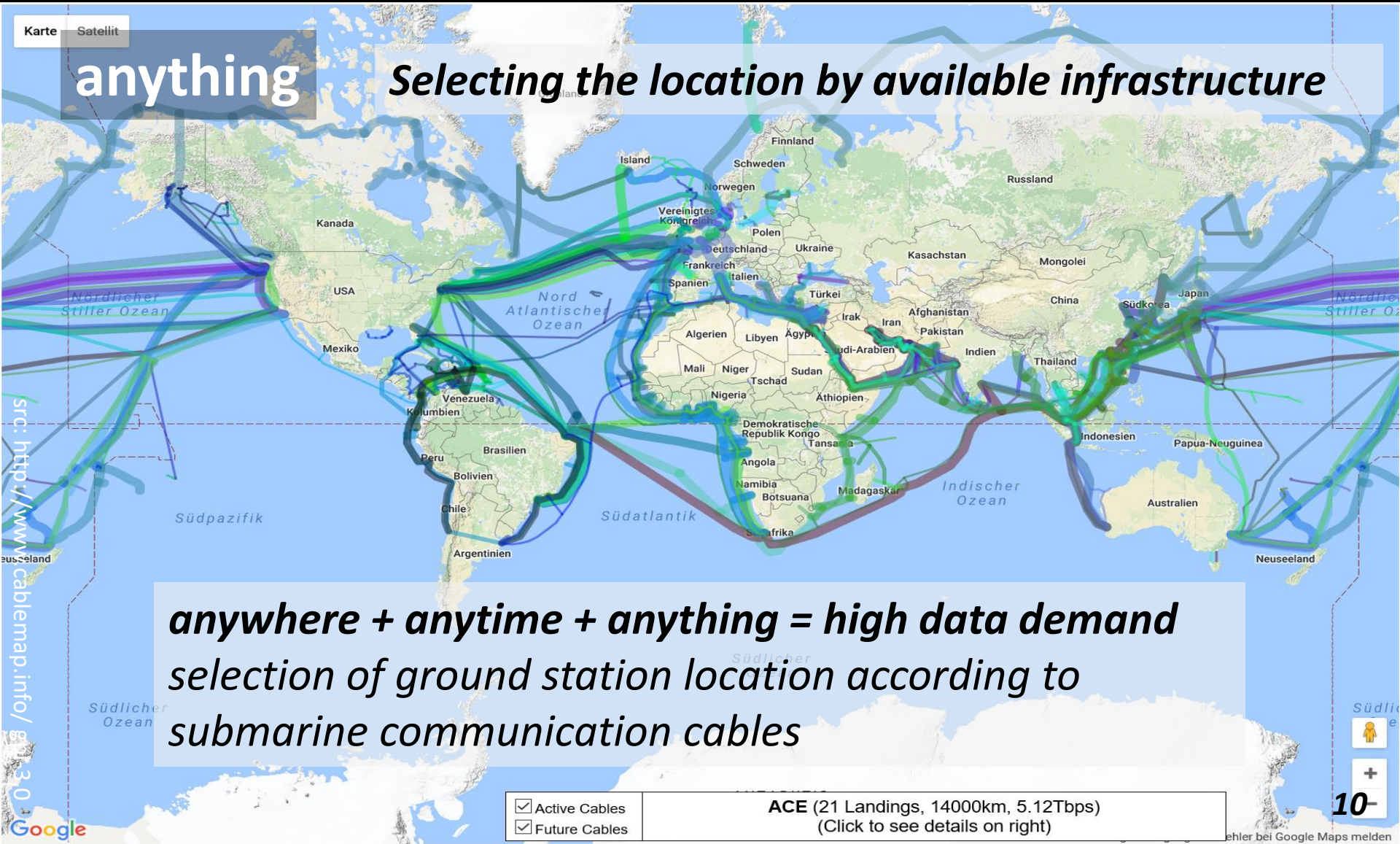
anywhere + anytime + anything = high data demand
selection of ground station location according to submarine communication cables

☑Active Cables
☑Future Cables

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

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Google

Ground Stations on sea cable landing points
similar contact times as on regular grid

Ground station network comparison by guaranteed transferred datasize

Paradigm Shift – comparison metric

guaranteed transferred data size per orbit
instead of **guaranteed data-rate**

$$G = \frac{data\ size\ per\ orbit}{infrastructure\ costs} = \frac{t_{\text{tracked}} * T_{\text{orbit}} * D}{n_{stations} * \text{€}_{station}}$$

GS (fixed antenna)
- elevation > 60°
- $\text{€}_{station}$ = 200€/station

GS (motorized)
- elevation > 10°
- $\text{€}_{station}$ = 500€/station

Guarenteed datasize per network investment [(Bit/Orbit)/€]

ground station number [-]

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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 accessible 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*
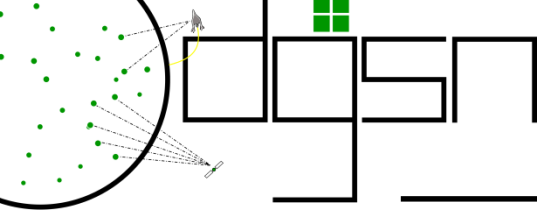
want to join a global internet-connected satellite tracking grid
or are you in need to find you missing CubeSat?
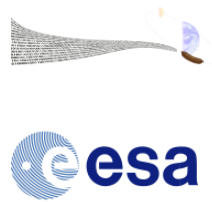
Distributed Ground Station Network

CreativeCommons By-NC-SA applies

Thank you for your attention!

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code on github.com/aerospaceresearch

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