Space Surveillance and Tracking (SST) e protezione planetaria:

un aggiornamento delle attività nazionali

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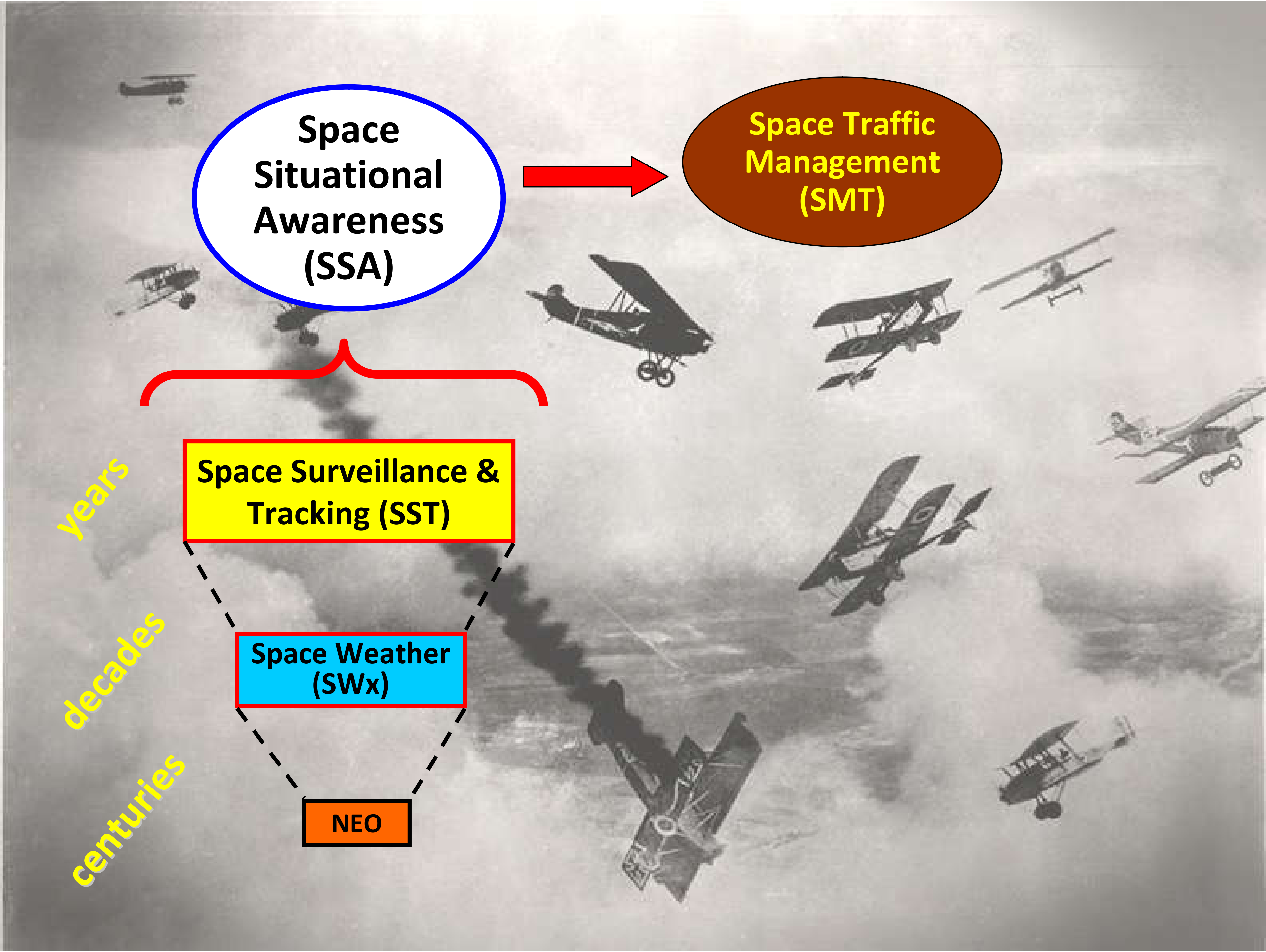
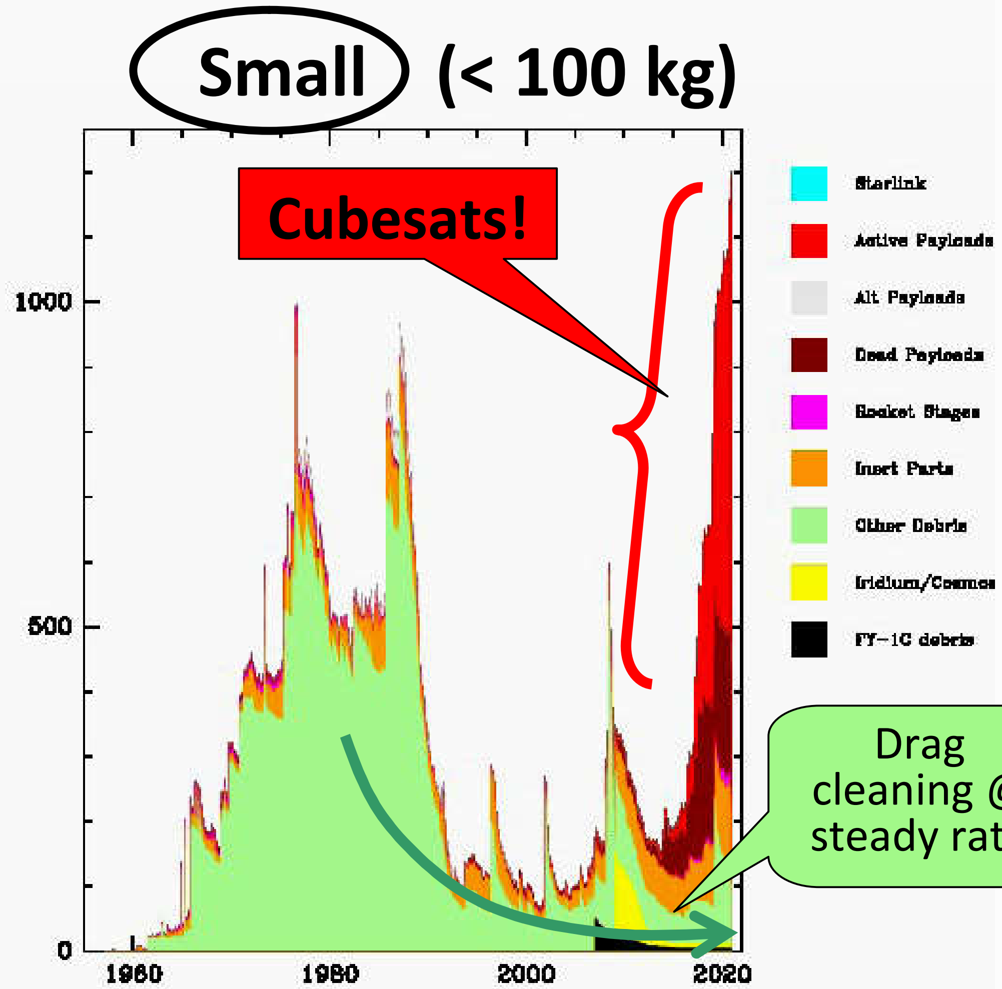
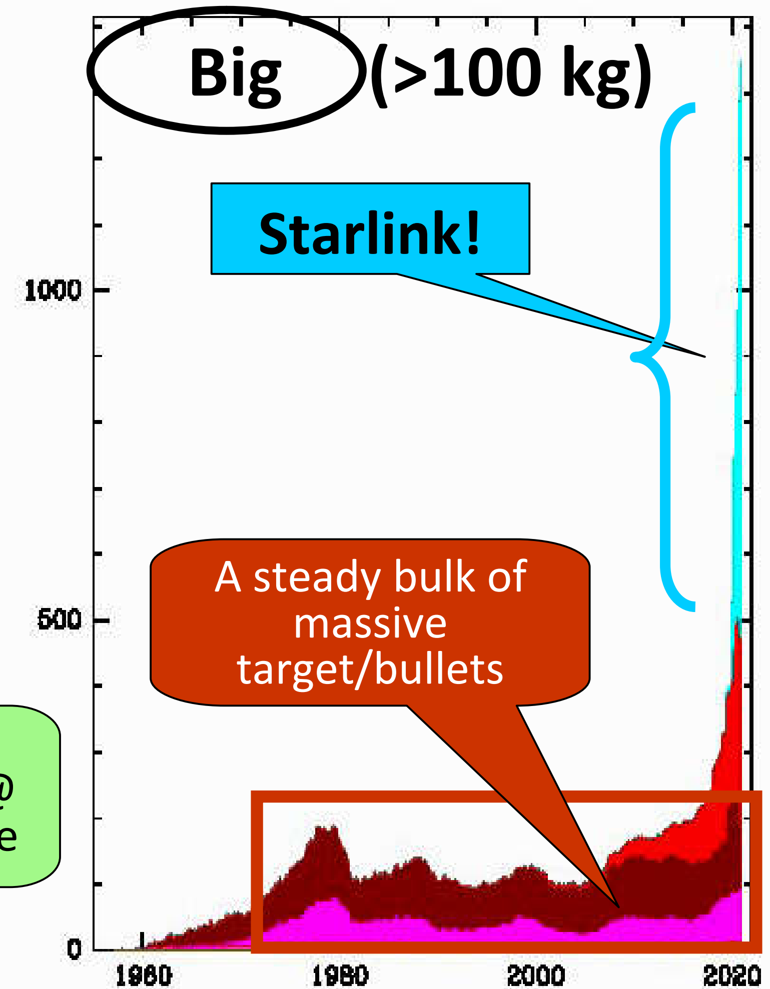

Space Situational Awareness (SSA)
Space Traffic Management (SMT)
Space Surveillance & Tracking (SST)
Space Weather (SWx)
NEO
years
decades
centuries

Bullets vs. Targets (LEO)



Bullets

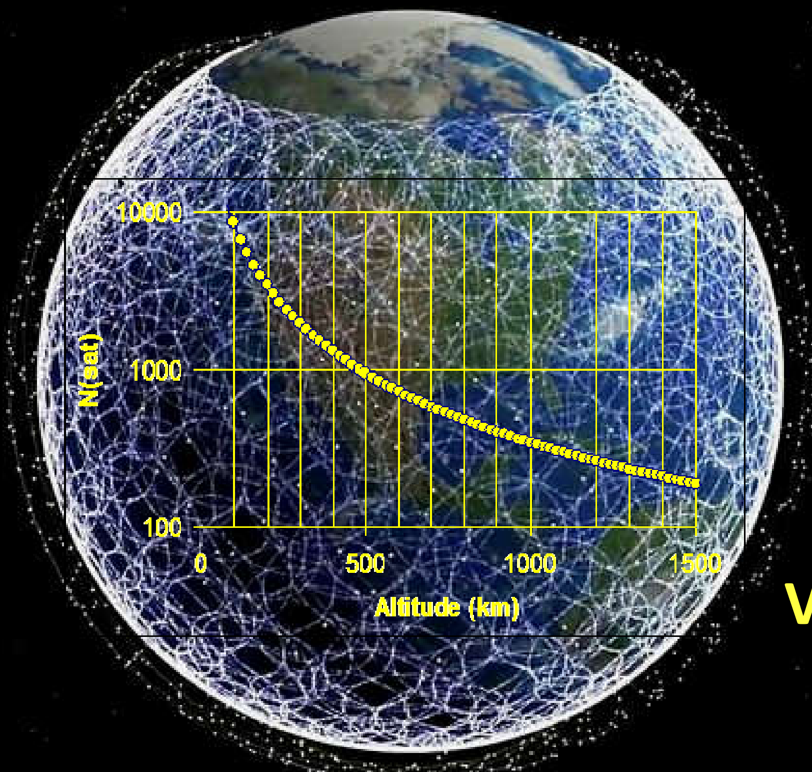


Targets

Credit: McDowell (2021), “Space activity in 2020: a progress report”

Satellite Mega-constellations

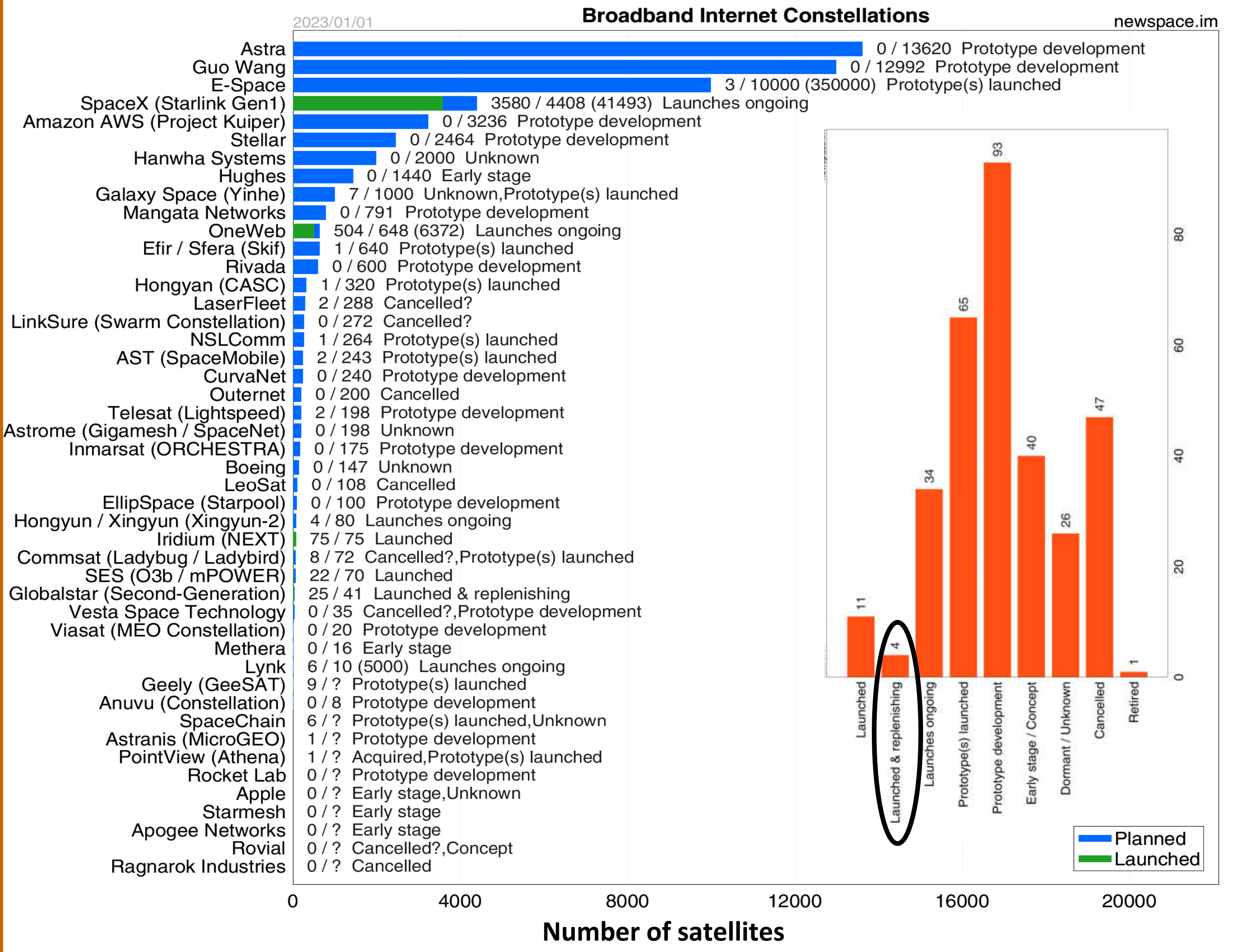
if Altitude ↓



Impact for:	manifacturer	astronomers
Lifetime:	↓	↓
Link budget:	↓	
On-board power:	↓	
Latency time:	↓	
Brightness:		↑
Crossing time:	↓	↓
Visibility timespan:		↓
Number:	↑	↑
Cost x satellite:	↓	
Cost x constl:	↑	

$$N_{sat} \propto \frac{1}{h(1+h)^{1/2}\, ar\cos[1/(1+h)]}$$

Satellite Mega-constellation: facts & status



The "pros" of ....

optical tracking

$$\frac{D_{radio}}{D_{opt}} = \frac{\nu_{opt}}{\nu_{radio}} \cong \frac{10^{15}}{10^{10}} \Rightarrow 10^{5}$$

1. A 1m optical telescope matches the angular resolution of a ~100 km radiotelescope/interferometer

$$f_{radio} = \left(\frac{L_{in}}{d^2}\right)\left(\frac{1}{d^2}\right) \Rightarrow$$

$$f_{radio} \propto d^{-4}$$

$$f_{opt} \propto d^{-2}$$

2. An optical telescope becomes more and more efficient than a bistatic antenna, with increasing distance

3. Operating costs for a 1m optical telescope are far less (<< 1/20) than costs for a LBI interferometer

An optical telescope is better **higher than ~2000 km** (H-LEO, MEO, GEO… NEO)

radar tracking

$$\frac{v}{c} = \frac{d\upsilon}{\upsilon}$$

1. Direct measurement of target (radial) velocity and distance (ranging), respectively through a Doppler shift and by pulsed echoes w/ typical accuracy of 50 meters

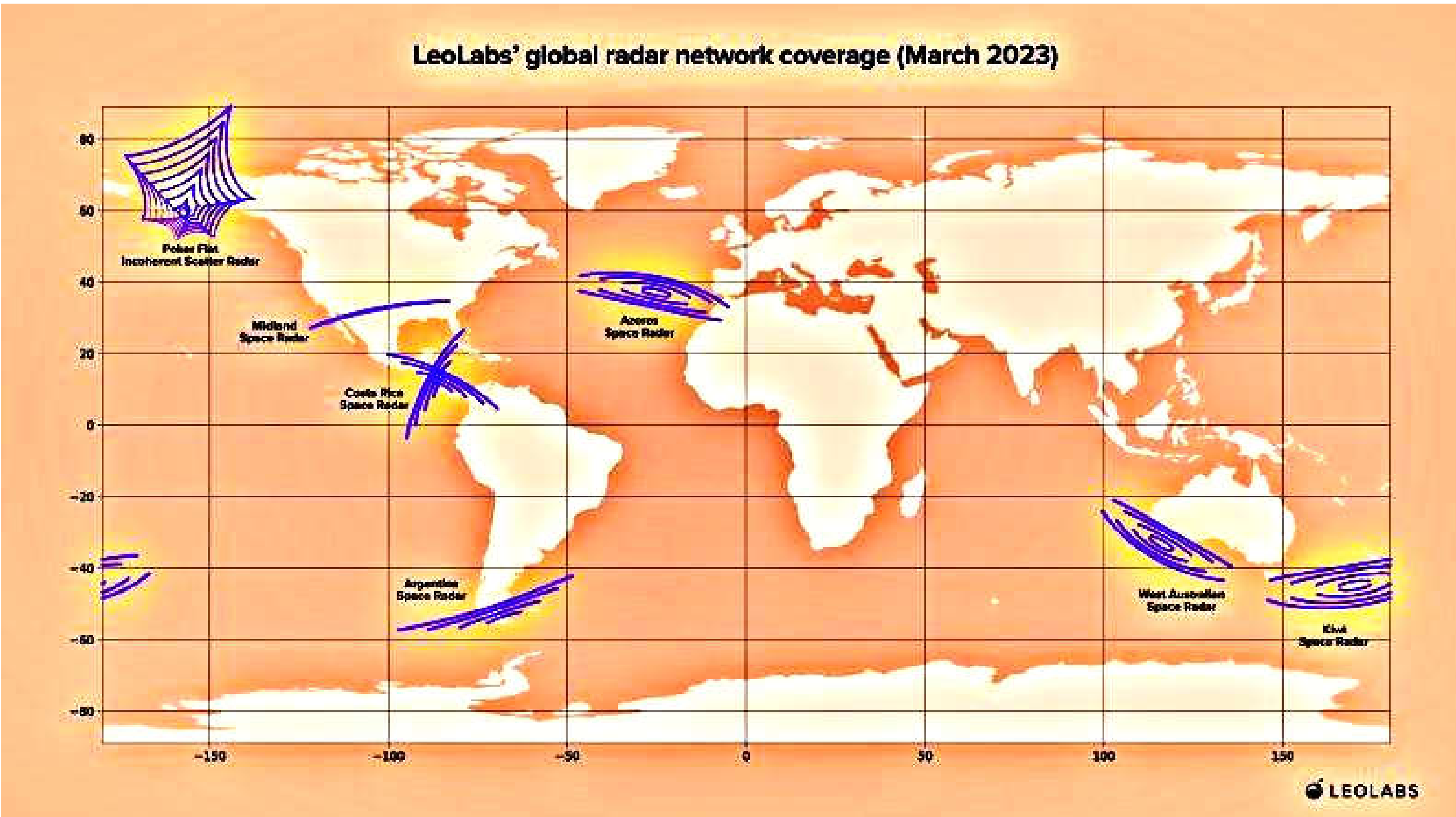
2. Observations can be carried out under daylight

3. Wider Field-of-View, about a factor of 20-30 larger w/ respect to a telescope

A radar/radiotelescope is better **lower than ~2000 km** (L-LEO, LEO)

The emerging commercial players: LeoLabs

Founded in 2016
HQ: Menlo Park, CA, USA
Cap. Worth: **82 M$**
Main stakeholders: Seraphim Space
Airbus Venture
Space Capital



The US SST telescope capabilities

AEOS (Advanced Electro-Optical System)

@ Haleakala Obs. (Hawaii, USA)

Optics: 3.67m f/200 (adaptive)

Slew: 20°/sec

7 Coude' splitter

US SST telescope

@ Exmouth, W. Australia

Optics: 3.5 m f/1.0 (Mersenne-Schmidt)

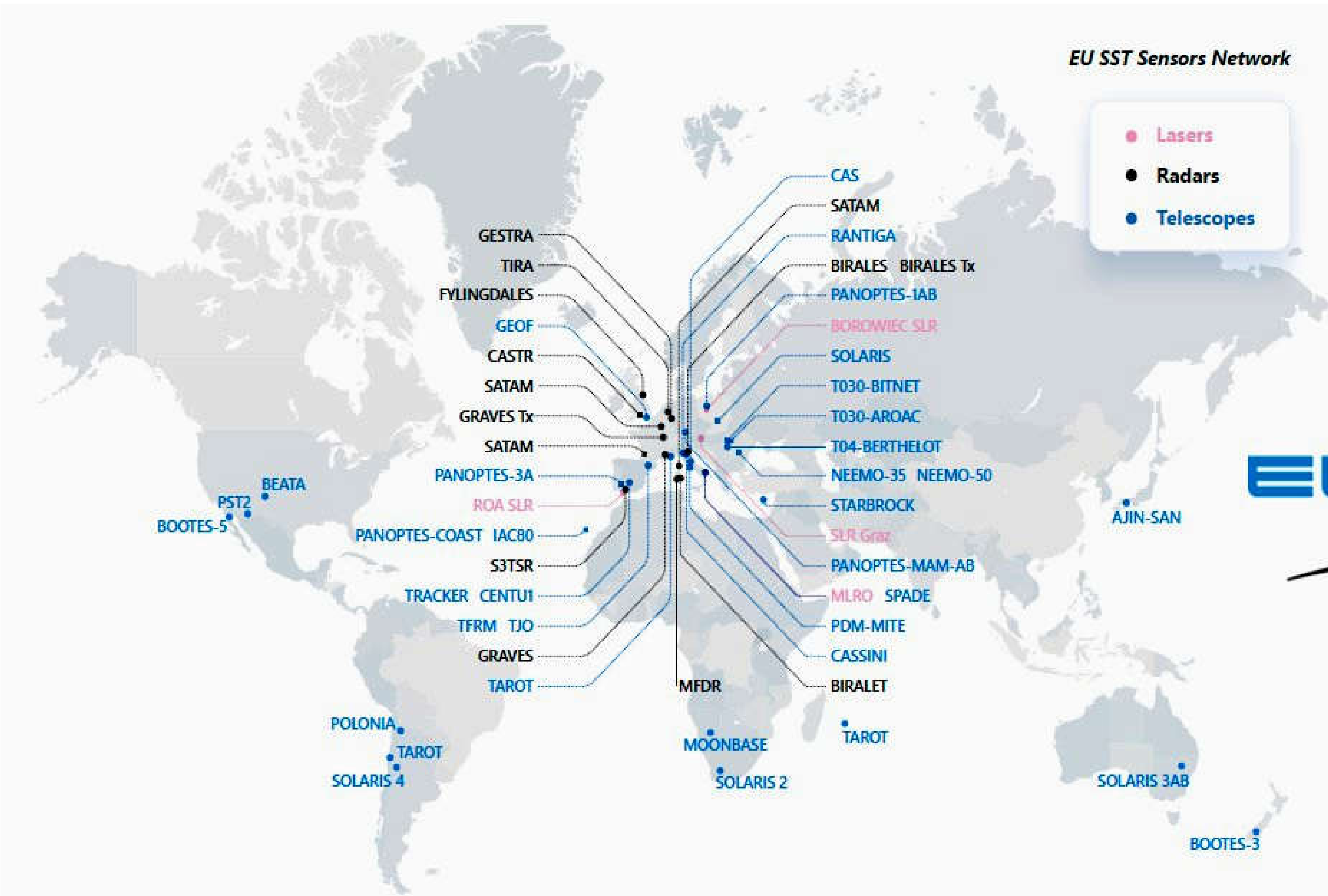
Array of 12 (curved) CCD detectors:

Each CCD: 2k x 4k = 8 Mpx
Px size: 15 µm (platescale: 0.9"/px)

FOV = 12 x 18 cm = 2.0° x 3.0°

The OKNO project
(Tagikistan)

The European Space Surveillance and Tracking Consortium (EU-SST)



as for 2022…

12 radars

35 telescopes

4 lasers

SSA/SST coordination in Italy

C-SSA @COA
Comando Operazioni Aerospaziali
Poggio Renatico (FE)

OCIS

Organismo di **C**oordinamento e di **I**ndirizzo delle attività relative all'iniziativa "**S**pace Surveillance and Tracking Support" (SST) della Commissione Europea

Agenzia Spaziale Italiana (ASI)

Istituto Nazionale di Astrofisica (INAF)

Stato Maggiore Difesa (MOD)

Aeronautica Militare

The Who-is-who of SST in Italy

PoliMi (DAER) – Milano
Camilla Colombo & Pierluigi Di Lizia
Orbital dynamics & Kessler Syndrome

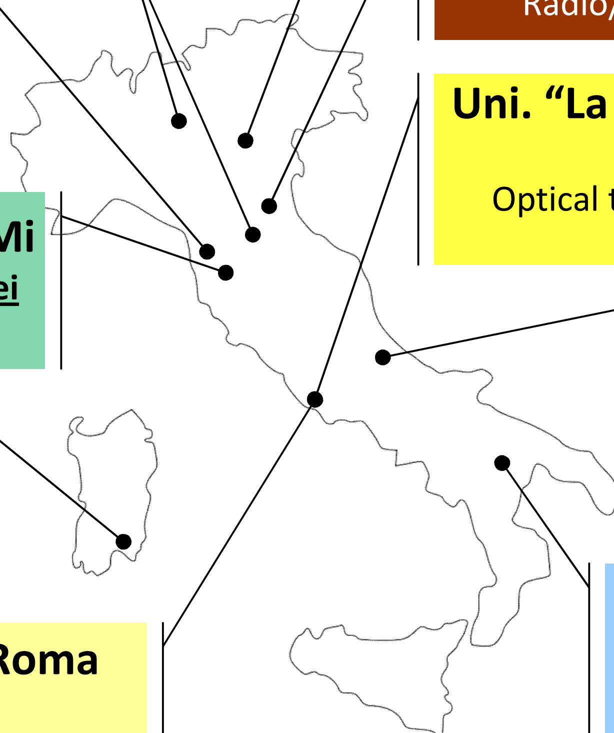
INAF (OAS) – Bologna/Loiano
Alberto Buzzoni
Optical tracking & study of space debris population

CNR (ISTI) – Pisa
Luciano Anselmo & Carmen Pardini
Physics of atmosphere re-entry

CNR (IFAC & IMATI) UniPi – Fi/Pi/Mi
Alessandro Rossi, Elisa M. Alessi, G. Tommei
Orbital dynamics & Kessler Syndrome

INAF (OAC) – Cagliari/Selargius
Tonino Pisanu
Radio/radar tracking of space debris

Uni. “La Sapienza” (SIA) – Roma
Paolo Teofilatto
Optical tracking & study of space debris population



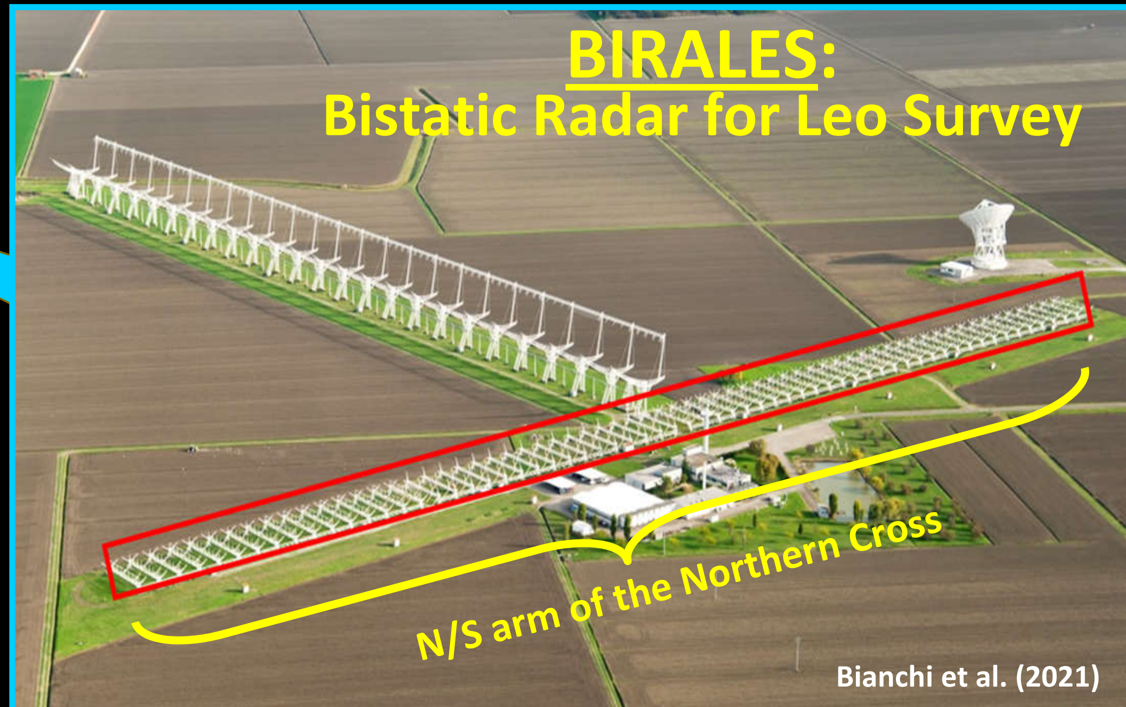
UniPd (CISAS) – Padova
Alessandro Francesconi
Physics of Hypervelocity impacts

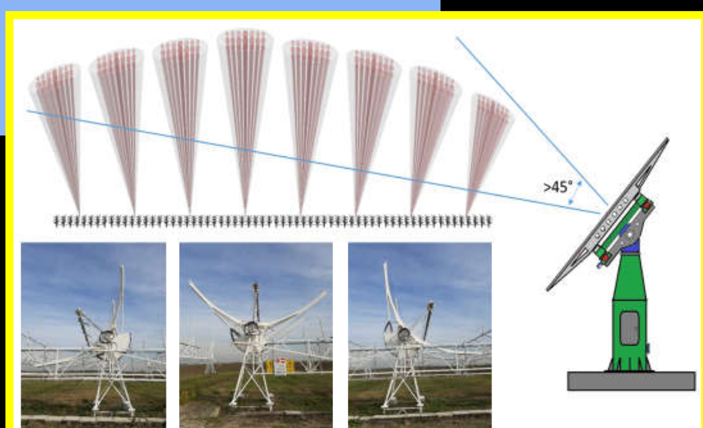
INAF (IRA) – Bologna/Medicina
Germano Bianchi
Radio/radar tracking of space debris

Uni. “La Sapienza” (DIMA) – Roma
Fabrizio Piergentili
Optical tracking & study of space debris population

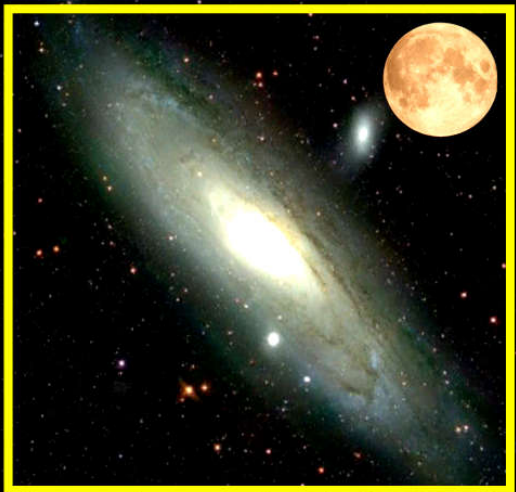
INAF (OAAb) – Teramo
Gaetano Valentini
Optical tracking & study of space debris population

ASI (Uff. SSA) – Rm & Mt
Cosimo Marzo
SST (optical & laser) & technology





	Current configuration	2023 Upgrade
FOV	7°x7°	7°x45°
# Detectable obj.	196/week	4964/week
# Detectable crossings	233/week	9141/week
Sensitivity @1000 km	10cm	5cm
Angular accuracy	0.6 arcmin	0.06 arcmin
Ranging accuracy	32m	32m



2.5° x 2.5°

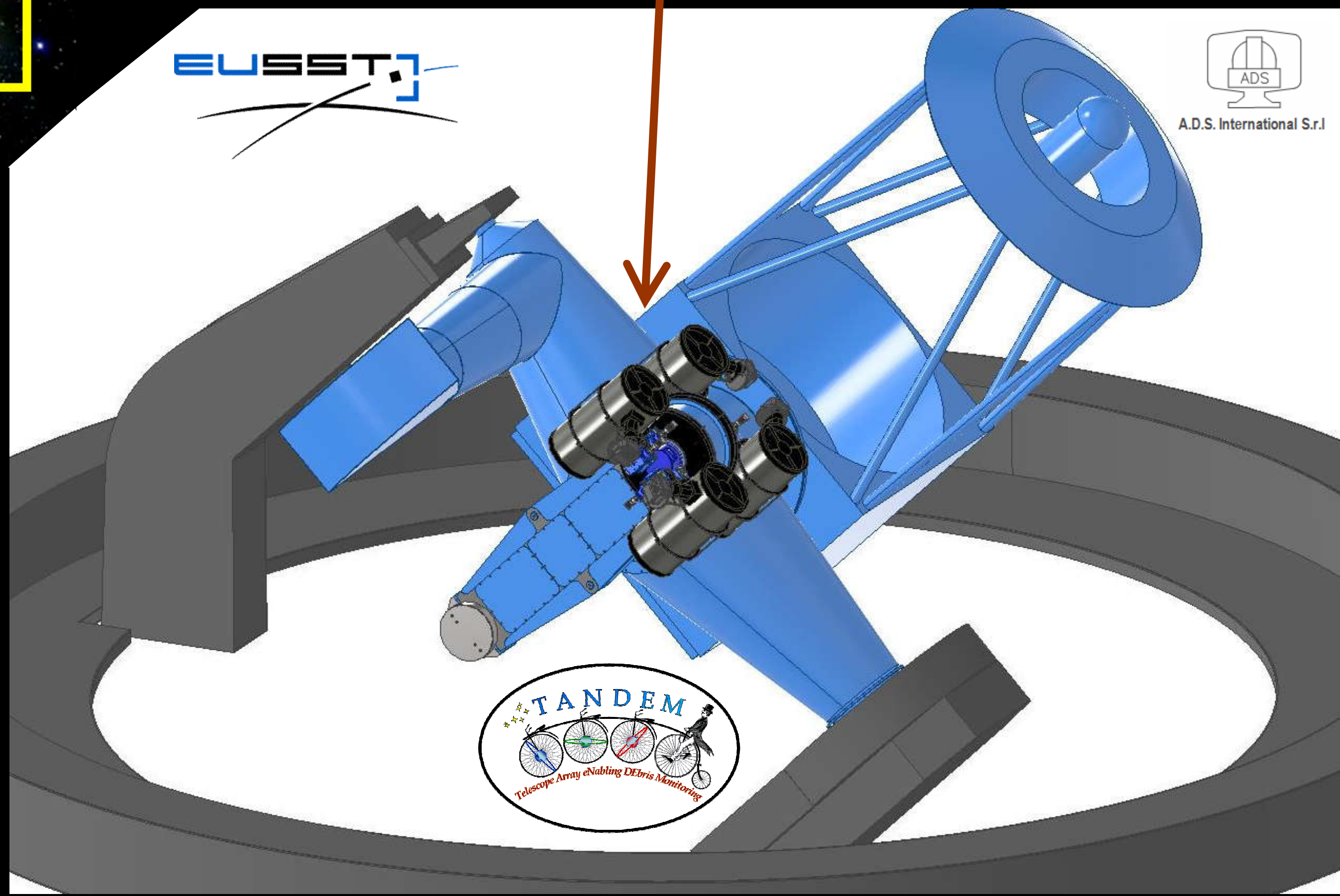
4x telescopes Ø 35 cm f/2.9

FOV = 20 $\square^2$ $V_{lim} \sim 18$

$\approx$

1 monolithic tel. Ø 70 cm f/1.4

FOV = 2.5° x 2.5° $V_{lim} \sim 20$



Telescope
Array
e**N**abling
DE**b**ris
Monitoring

Buzzoni et al. (2022)

The Fly-Eye telescope(s)

- 1 telescope owned by **ESA** (NEOSTEL) [ready] → Mufara (PA)
- 1 telescope owned by **ASI** [TBD – 2028] → Matera (ASI)
- 3 telescopes by **ASI** via PNRR [TBD – 2027] → Chile/Australia/Arizona?
- Main contractor: OHB Italia

- Optics: 1.15 m f/1.7 (Schmidt)
- FOV: 6.7° x 6.7° (split into 16 CCDs)
- Slew: 7°/sec
- Mass: 23 tonnes

Costs breakdown for NEOSTEL

Italy	35%
Romania	13%
Poland	13%
Germany	13%
Czech Rep	4%
Spain	7%
Norway	5%
Luxembourg	9%

Cost: 8.1 M€ (2017)