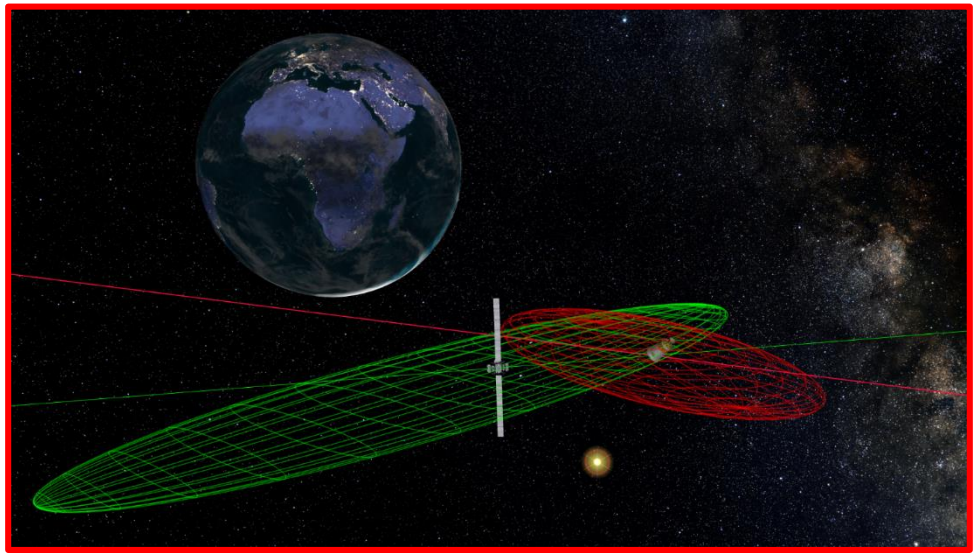
SPACE DATA ASSOCIATION

Future STM Capabilities



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Dr Mark Dickinson, Chairman Space Data Association

(Deputy CTO, Inmarsat)

ESPI Autumn Conference, Vienna, 27-28 Sept 2018

Overview

- Formed in 2009, the Space Data Association (SDA) is a formal, non profit association of civil, commercial and military spacecraft operators that supports the controlled, reliable and efficient sharing of data that is critical to the safety and integrity of satellite operations
- SDA has a legal structure and agreements that provide protections and enforcement mechanisms to ensure data is only used for intended purposes
- The Space Data Association relies on the Space Data Center (SDC) developed and operated by our technology partner AGI , for flight safety data exchange and processing
- The Space Data Center (v1.0) is reliable, geographically redundant and secure. SDC 1.0 relies on:
  - Operator ephemeris with integrated maneuver data for members (most accurate)
  - TLE (Two Line Elements) or SP (Special Perturbation) from JSpOC catalog for all other objects (less accurate)

SPACE DATA ASSOCIATION

SDA: 34 members and participants, 615 satellites, 62% of active GEO

Objectives

- Promote responsible behaviours from operators in all orbital domains to ensure the protection of key assets and the space environment
- Provide members with a system (SDC) to enhance safety of flight
- Improve the accuracy of collision avoidance predictions
- Take advantage of other opportunities for data sharing. Safe operations is more than orbits e.g. cyber and RF interference
- Working with all interested entities to help define the next generation of STM systems and capabilities

Limitations of Legacy Systems and Data

- **Public Catalog**
  - Covariance time histories and VCM covariances unavailable.
  - Timeliness: SP ephemeris is typically up to 2 days old before delivered to SDC
  - GEO catalog omits potentially hundreds of RSOs > 20 cm
  - Susceptible to cross-tagging & track mis-association due to undersampling
  - Planned sensor improvements offer minimal GEO improvement
  - Lack of sensor site diversity leads to increased weather-related outages
- **Operator Provided Data**
  - Inability to estimate requested/desired collision avoidance Go/No-Go criteria
  - 95th percentile 1.2 km error after a day of propagation; renders 1.e-4 Probability of Collision (Pc) unachievable
  - Covariance time histories (required to generate Pc estimates) are not available for most operators
  - Majority of operators do not participate in Orbit Determination Independent Verification &Validation; which leads to unknown orbit quality
  - Operators ephemerides update periods vary, some being up to 8 days
  - Biases in operators network leads to an average position error of >3km resulting in missed conjunction warnings and unnecessary avoidance maneuvers being performed
- **The majority of operators do their best with the currently systems and data available. However, often the conjunction warnings received are not actionable or provide a false sense of security**
- **Advancements in capabilities (e.g. EU SST) with additional sensors is highly welcomed**

Limitation of Current Public Catalogue

Category	Public Catalogue
Space Traffic Management	
1 Free to operator	Paid by US taxpayer
2 Prioritized to meet STM customer needs	Military mission
3 Comprehensive STM services (CA, RFI, Wx)	CA only
4 High SLA for timely, accurate CA & RFI	No SLA & no RFI
5 Legal protection of IP	No protection w/in USG
6 Flexible, user-config M2M & User Interface	
7 Transparent processes, results	
8 STM roadmap will address deficiencies	

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Space Situational Awareness	
9 Complete GEO-crossing catalog > 1 m	Complete
10 Complete GEO-crossing catalog > 20 cm	Incomplete
11 Object sizes and/or RCS for debris	Largely unavailable
12 Object size for SDA satellites	Not incorporated
13 Quality control process	?
14 Meets/exceeds established security stds	?
15 Avoids cross-tags, track misassoc.	
16 Responsive sensor scheduling	(task-based, w/no sched.)
17 Decision-quality Pc	20 m HBR; unrealistic covar

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Sensor network	
18 Frequent sensor calibration	1X/2 wks
19 Large, diverse sensor network	12 Grd opt, 3 spare, 17 radar
20 Distrib. optical ground sites (Wx, viewing)	3 sites
21 Powerful radar sensors	Numerous contrib. radars
22 Passive RF for exquisite OD and ΔV detect.	
23 Space-based	

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Orbit Determination (OD) and prediction	
24 Passed JMS orbit accuracy tests (NumVal)	
25 OD explicitly models sensor & force uncert.	4 days left (SP) & no covar
26 Covar predicts include force model, ΔV σ	
27 Ephem, covar time histories next 10 days	
28 Accommodates ΔV(s) w/in OD timespan	
29 Can incorporate planned ΔVs	
30 Force model fully shared (DCA if used)	Will not be shared
31 Timely Orbit Determination (OD)	1.7 days (TLE), 1.5 days (SP)
32 Accommodates obs from any sensor type	
33 Can fuse O/O, optical, radar, passive RF	
34 Can fuse obs w/ΔV history & planned ΔVs	
35 Can propagate thru 3D ΔVs = f(t)	
36 Realistic covariance in low LEO	Too low for DCP
37 Realistic covariance in mid-LEO	DCP approach works here
38 Realistic covariance in high-LEO	Lack of drag nullifies DCP
39 Realistic covariance in GEO	SCP ineffective
40 OD product accuracies support Pc~1.e-4	
41 Wide mix of atmosphere, SRP, grav models	
42 Low thrust capable	

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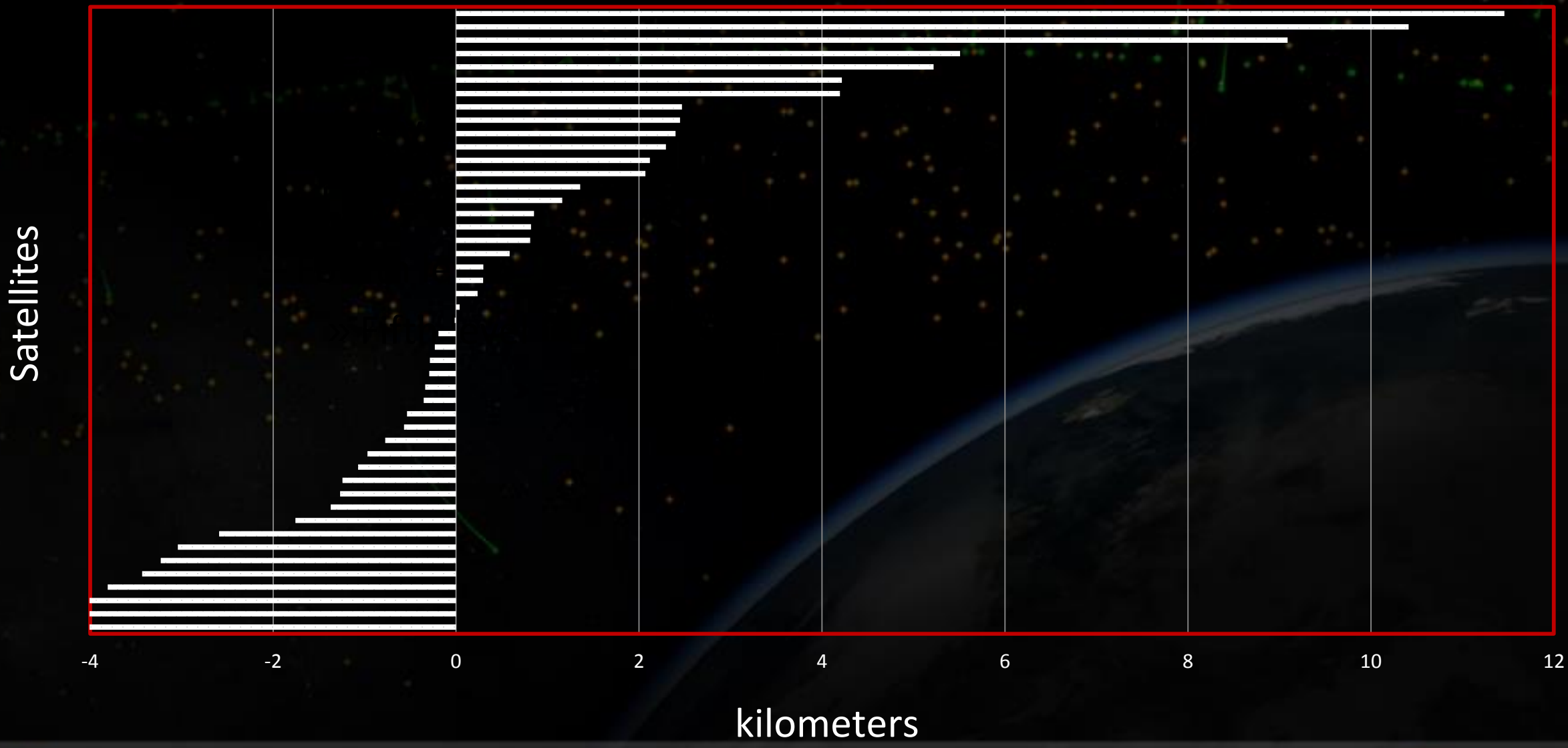
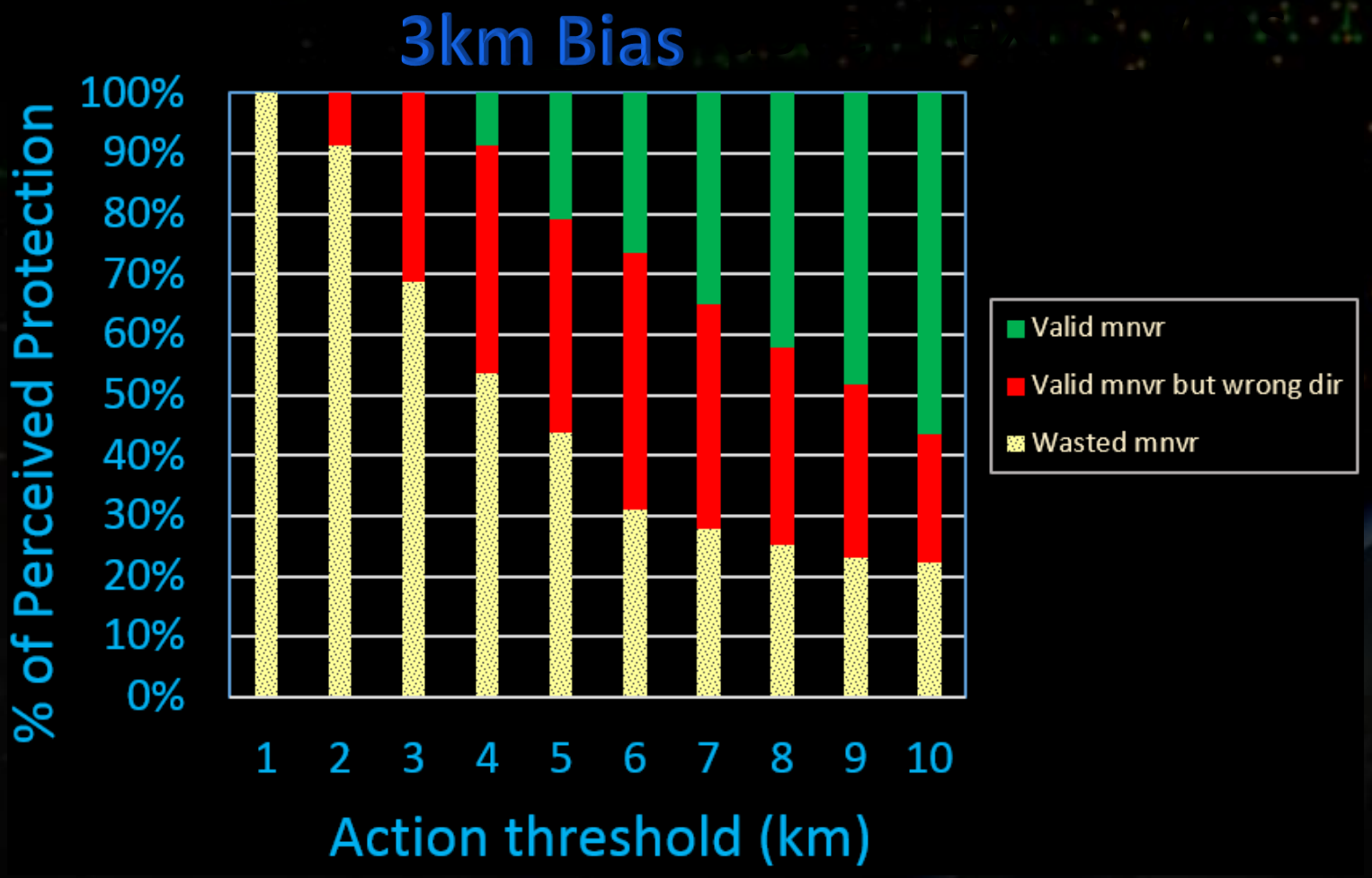
Conjunction assess and collision avoidance	
43 CA product availability past perf	12% SP Eph & 6% covar unavail
44 Decision-quality CA products over 10 days	< 4 days viable SP
45 1.e-4 Pc readily achievable	TLEs do not support; SP maybe
46 Nonlinear Pc	
47 Can remove in-fleet CA	
48 Collision avoidance ΔV planner and tester	Will confirm ΔV works

Inconsistent accuracy



Impact of bias on risk mitigation



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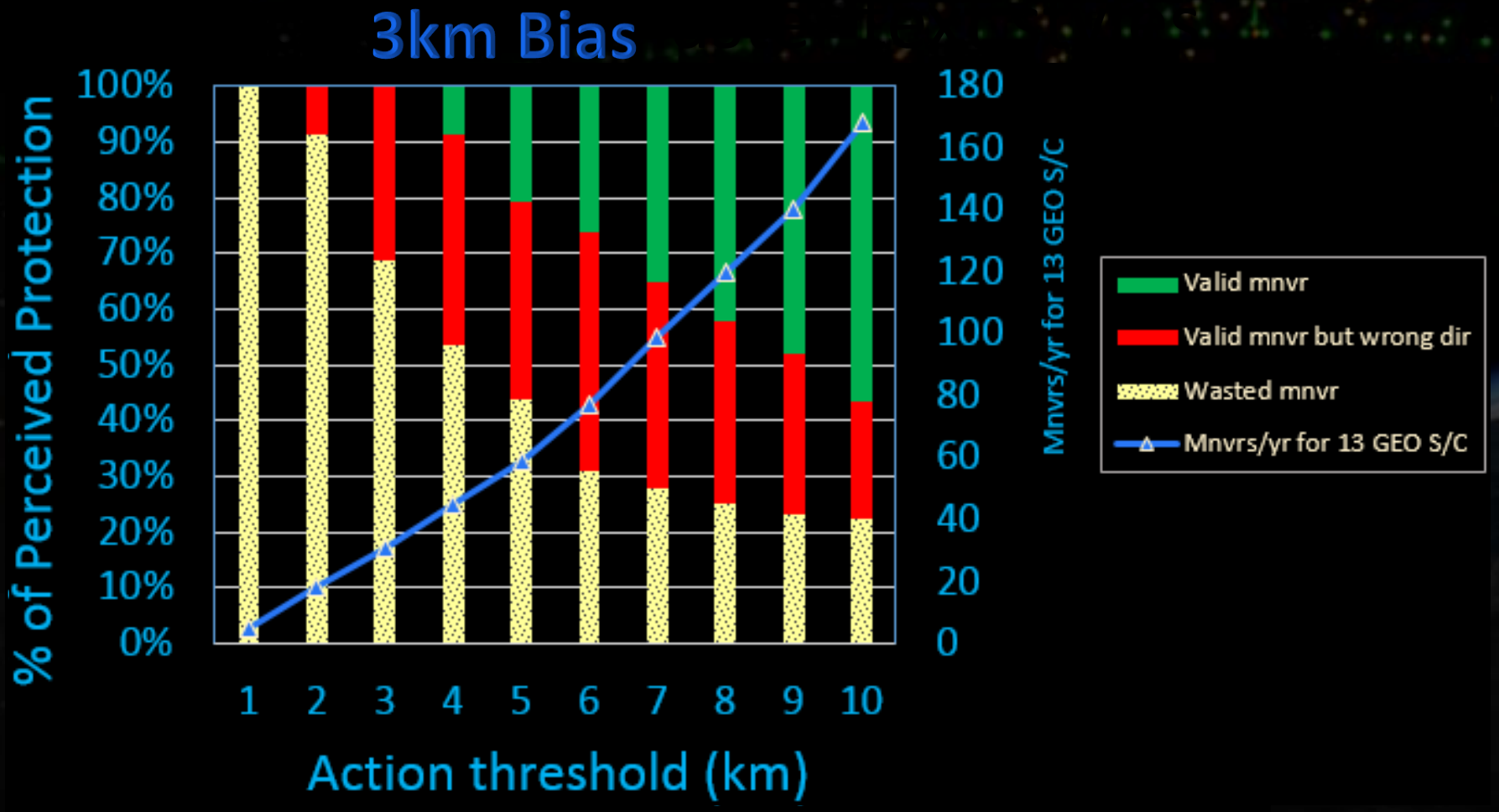

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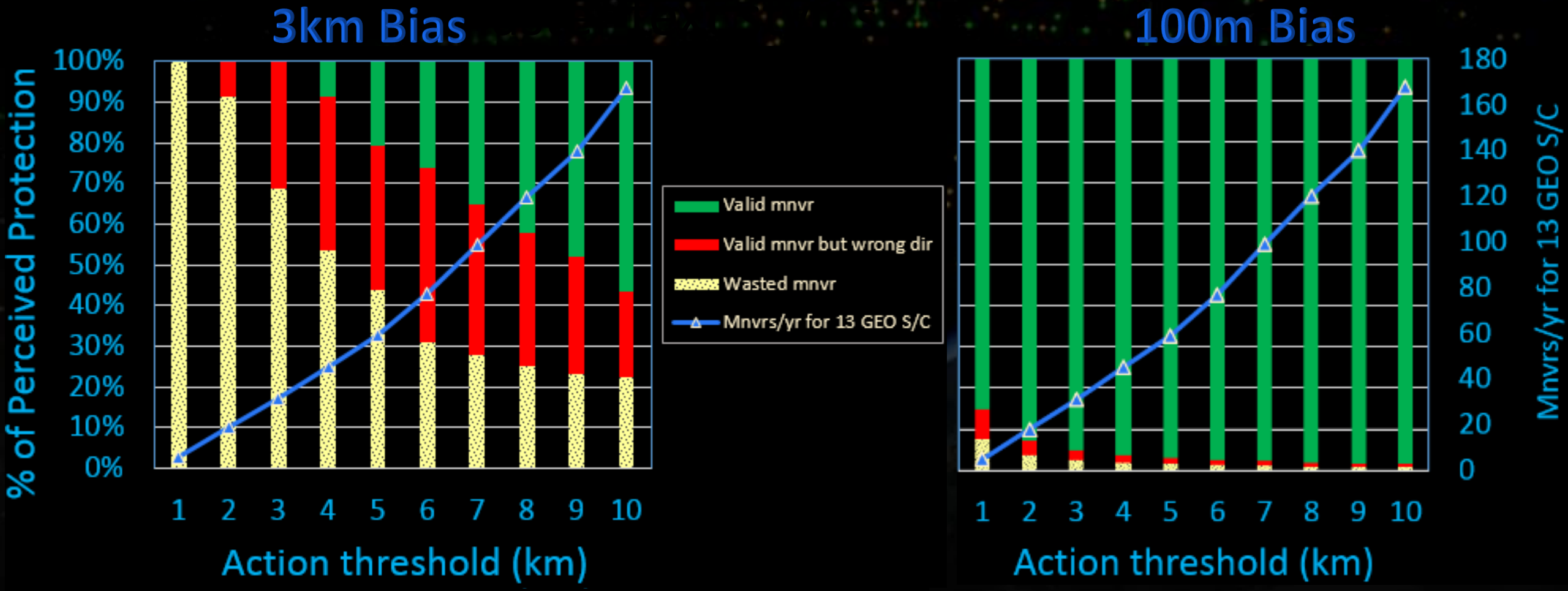

Next Generation STM System

- The SDA members have been studying the requirements for the next generation STM systems. The highlighted limitation clearly demonstrate the need to have new capabilities to ensure the long term protection of the space environment and provide actionable operational products
- Working with all stakeholder: governments, agencies, operators and industry
- Identified key attributes:
  - Pooling sensor data from multiple sources and entities
  - Data transparency (source, age, quality, accuracy)
  - A clearing house function to validate input data
  - All operators provide safety of flight data (e.g. ephemerides, physical properties)
  - Accurate and consistent orbit propagation algorithms
  - Available to all (someone else's problem/inaction can become my problem)
- SDA attempted to provide these capabilities via SDC 2.0, but reluctance by commercial and institutional operators to pay for these capabilities/mitigate the risks ahead of any future government (USG, EU) provided enhanced ‘free’ services
- The SDA is uniquely positioned to provided inputs in discussions on future STM

How to become a member?

Visit space-data.org