Schedule and Cost Estimating Analysis for LEO Satellite Constellations

Brian G. Gladstone

Patricia F. Bronson

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Institute for Defense Analyses

730 East Glebe Road ● Alexandria, Virginia 22305

Are There Simple Methodologies to Estimate Realistic Lifecycle Costs and Schedules for Large Satellite Constellations?

Commercial example:
Starlink Mission, 60 satellites, May 2019

Image: SpaceX

Government example:
SDA's T0TL, T1TL, T1TR, T2TL, etc.

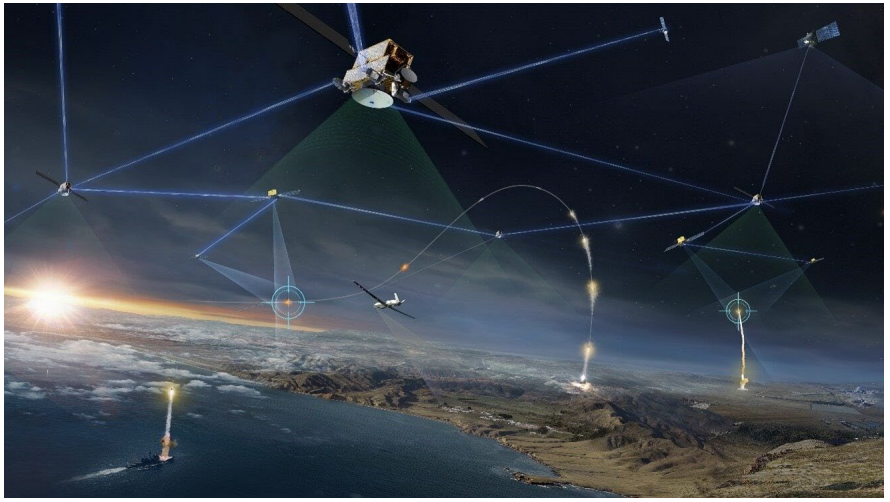
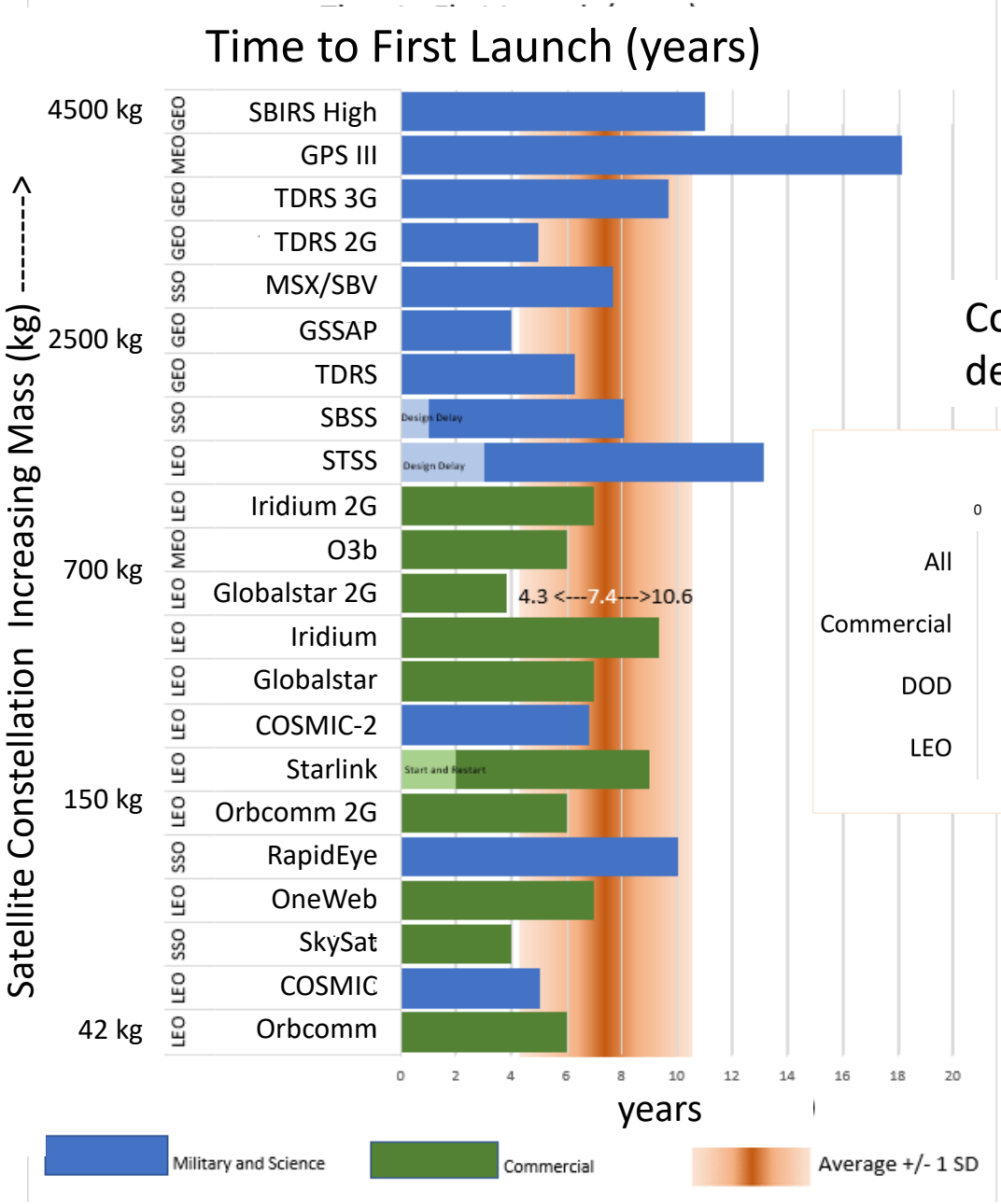


Image: Northrop Grumman

Cost Data For Low Earth Orbit Constellations

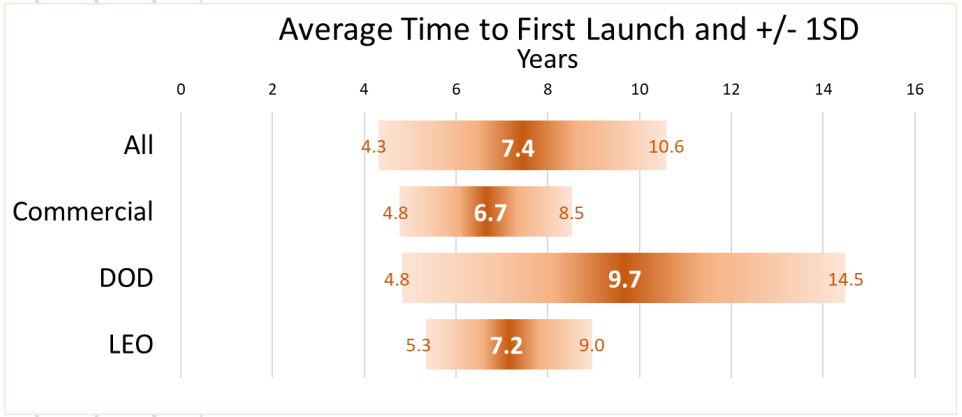
Constellations	Generation	Number of satellites	SATCOM	Commercial	Mass (kg)	Time to first launch (years)	Year of 1st launch	Lifetime (years)	Orbital Altitude (km)	Constellation Acquisition Cost (CY22 $M)
COSMIC	1	5	0	0	70	5.0	2006	5	700	111
COSMIC-2	0	6	0	0	278	6.8	2019	5	710	233
Orbcomm	1	28	1	1	42	6.0	1995	4	661	514
Globalstar 2nd Ger	0	24	1	1	700	3.8	2010	15	1,410	934
SBSS	1	11	0	0	1,031	7.1	2010	7	630	1,167
MSX/SBV	1	1	0	0	2,700	7.6	1996	26	898	1,514
STSS	1	2	0	0	1,000	10.1	2009	12	1,350	2,342
Globalstar	1	52	1	1	450	7.0	1998	8	1,410	2,976
Iridium 2nd Gen	0	81	1	1	860	7.0	2017	13	780	3,202
OneWeb	1	428	1	1	147	7.0	2019	7	1,200	4,011
Iridium	1	98	1	1	689	9.3	1997	8	780	7,488
Starlink	1	1,737	1	1	260	7.0	2018	6	550	10,400

Historical Commercial and Government Satellite Constellation Development Schedules



Not shown: numerous commercial and government cancellations

Constellation sub-classification and development schedule ranges



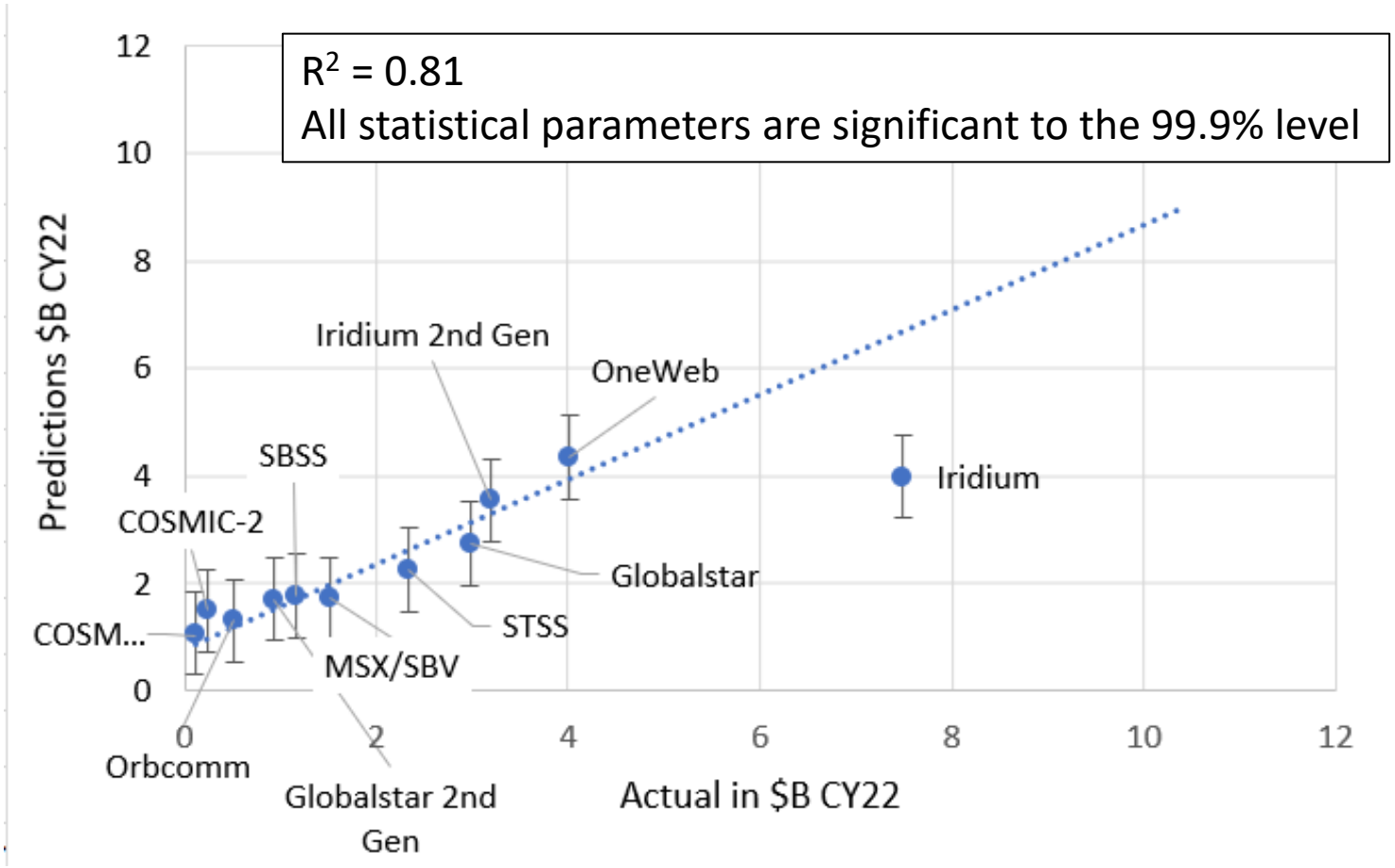
Cost Methodologies

Modeled total constellation cost using multiple linear regression techniques with various combinations of logical independent variables

Total constellation replenishment costs considers the number of orbital planes, assumed reliability of the satellites, and applied a premium for high priority launches

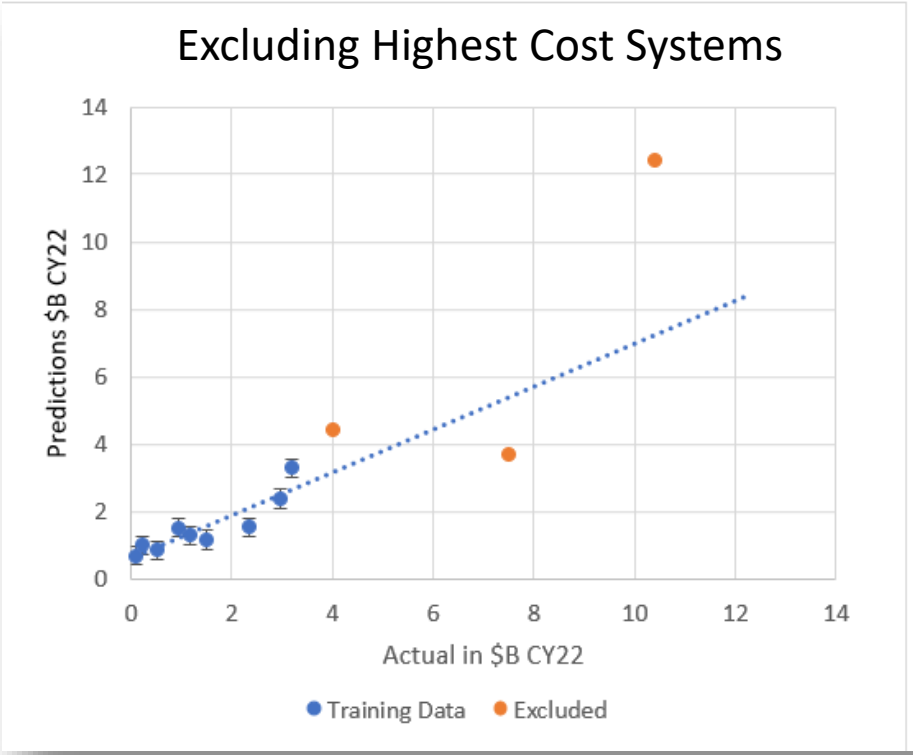
IDA's Cost Model for Megaconstellations

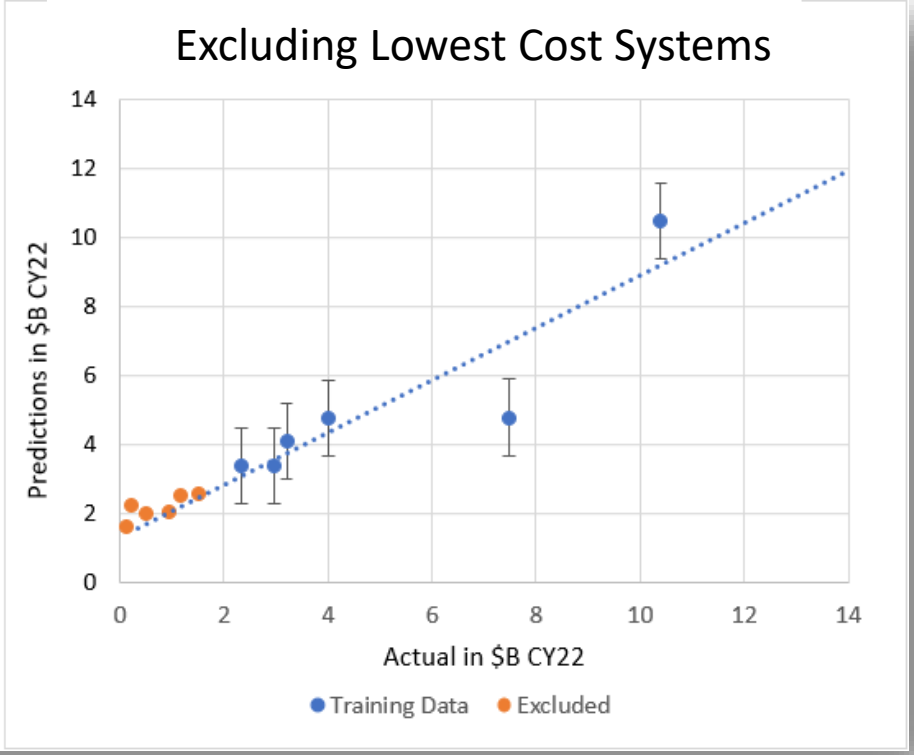
CER ($M) = $213M/year * (Development Time, years) + $3.78*10^-5 M/kg*km*N * (MAN[1], kg*km*N)



[1] MAN is the physics-based synthetic variable: Mass (kg) *Altitude (km) *Number of satellites.

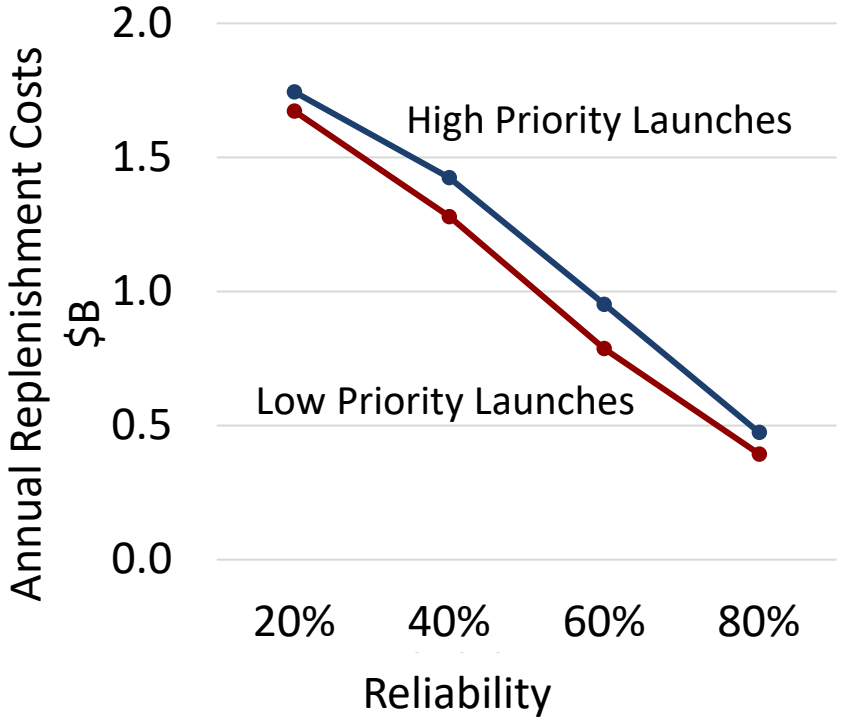
IDA's Cost Model for Megaconstellations Is Decent at Predictions Out of Set





IDA's Paper Describes Robust and Simple Parametric Megaconstellation Cost and Schedule Models, with Reasonable Explanatory and Predictive Power

Replenishment cost model's predicted annual cost ranges for SDA's T1TL constellation



Acquisition cost model's predicted cost ranges for LightSpeed and SDA's T1TL