



NASA Instrument Cost Model for Explorer-like Mission Instruments

NICM-E

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Motivation



- The NICM team received feedback that NICM was predicting costs much higher than grass roots estimates for many Explorer class mission instrument proposals
- Previous Explorer class instruments were found to have lower actual costs compared to the other instrument costs in the NICM database.
- Why is this? A class of instruments was identified that contrasts with the rest of the NICM instruments in the following way:
 - Flew on Class C missions AND
 - University or research foundations led and performed the majority of the instrument development (design through delivery) AND
 - Significant inheritance
- The NICM Team set out to create a new CER which would be applicable to this class of Explorer-like mission instruments.

Objective



- A. To create a new Cost Estimating Relationship (CER) for instruments with the following characteristics:
 1. Flew on C Class Missions AND
 2. University or research foundations led and performed the majority of the instrument development (i.e. design through delivery) AND
 3. Significant inheritance
- B. To determine if this new CER is indeed needed in addition to the traditional NICM CERs.

Methodology



- Collect and normalize Explorer class mission instrument data
- Identify key cost drivers for this data using principal components analysis
- Develop a Cost Estimating Relationship (CER) using the identified cost drivers
- Validate the CER using bootstrap cross validation
- Compare the utility of this new CER to the traditional NICM CERs
- Create recommendations for the new CER use

Data Collection and Evaluation



- Data Collection and Common Characteristics
 - Collected instrument technical and programmatic data for 20 instruments on missions led by Goddard, JPL and APL.
 - Note that 2 of these instruments did not fly on Explorer class missions, but did have the 3 main characteristics and thus were included
 - Note that 8 instruments are Optical, 4 are Fields, 8 are Particles and there are no Microwaves
- Data Evaluation
 - Converted to same fiscal year as traditional NICM data, \$FY2004
 - Normalized cost data where appropriate
 - Verified risk class
 - Determined design inheritance (i.e. previously flown instruments, subsystems/components, etc.)
 - Determined university and research foundation involvement

NICM-E Instrument Data



Instrument Name	Lead Center	Instrument Type	Sensor Cost (\$K FY04)	B/C/D Cost (\$K FY04)	Mass (kg)	Maximum Power (W)
CHIPS	GSFC	Optical	\$4,521	\$5,014	23.67	30.00
CIPS	GSFC	Optical	\$7,010	\$10,483	24.00	39.00
EFI THEMIS	GSFC	Fields	\$2,308	\$2,904	16.01	13.73
EFPE	GSFC	Fields	\$5,730	\$7,161	28.45	15.90
ESA FAST	GSFC	Particles	\$4,880	\$6,100	23.97	13.10
ESA THEMIS	GSFC	Particles	\$1,176	\$1,480	3.85	1.77
GALEX	JPL	Optical	\$18,609	\$23,662	135.10	191.00
GUVI	APL	Particles	\$6,105	\$8,355	19.07	26.69
IRIS	GSFC	Optical	\$20,746	\$28,917	97.30	96.30
LEICA	GSFC	Particles	\$2,424	\$3,030	9.76	9.32
MAG-FAST	GSFC	Fields	\$1,680	\$2,100	7.03	2.10
MAST/PET	GSFC	Particles	\$2,776	\$3,470	11.27	8.01
NuStar	JPL	Optical	\$36,870	\$42,275	179.00	200.00
RHESSI	GSFC	Optical	\$21,904	\$30,669	127.00	175.20
SOFIE	GSFC	Optical	\$6,346	\$9,996	38.00	52.00
SST	GSFC	Fields	\$1,244	\$1,566	1.74	1.38
TEAMS	GSFC	Particles	\$2,480	\$3,100	10.31	4.50
TIDI	APL	Particles	\$12,700	\$16,081	40.57	53.00
TRACE	GSFC	Optical	\$19,116	\$23,895	59.13	69.00
ULEIS	APL	Particles	\$6,260	\$7,512	18.40	21.20

New CER and Validation Results



- Principal Component Analysis determined instrument mass and maximum power to be the two main sensor cost drivers:

$$\text{Cost (\$K FY04)} = 661 M^{0.43} P^{0.34}$$

- High coefficient of multiple correlation of 93% with a standard error of 29%
- Prediction Error from Bootstrap Cross Validation with 10,000 samples is 30.4%, i.e. to obtain 70% confidence the CER cost (i.e. median cost) is only increased 16%

NICM-E vs. Traditional NICM

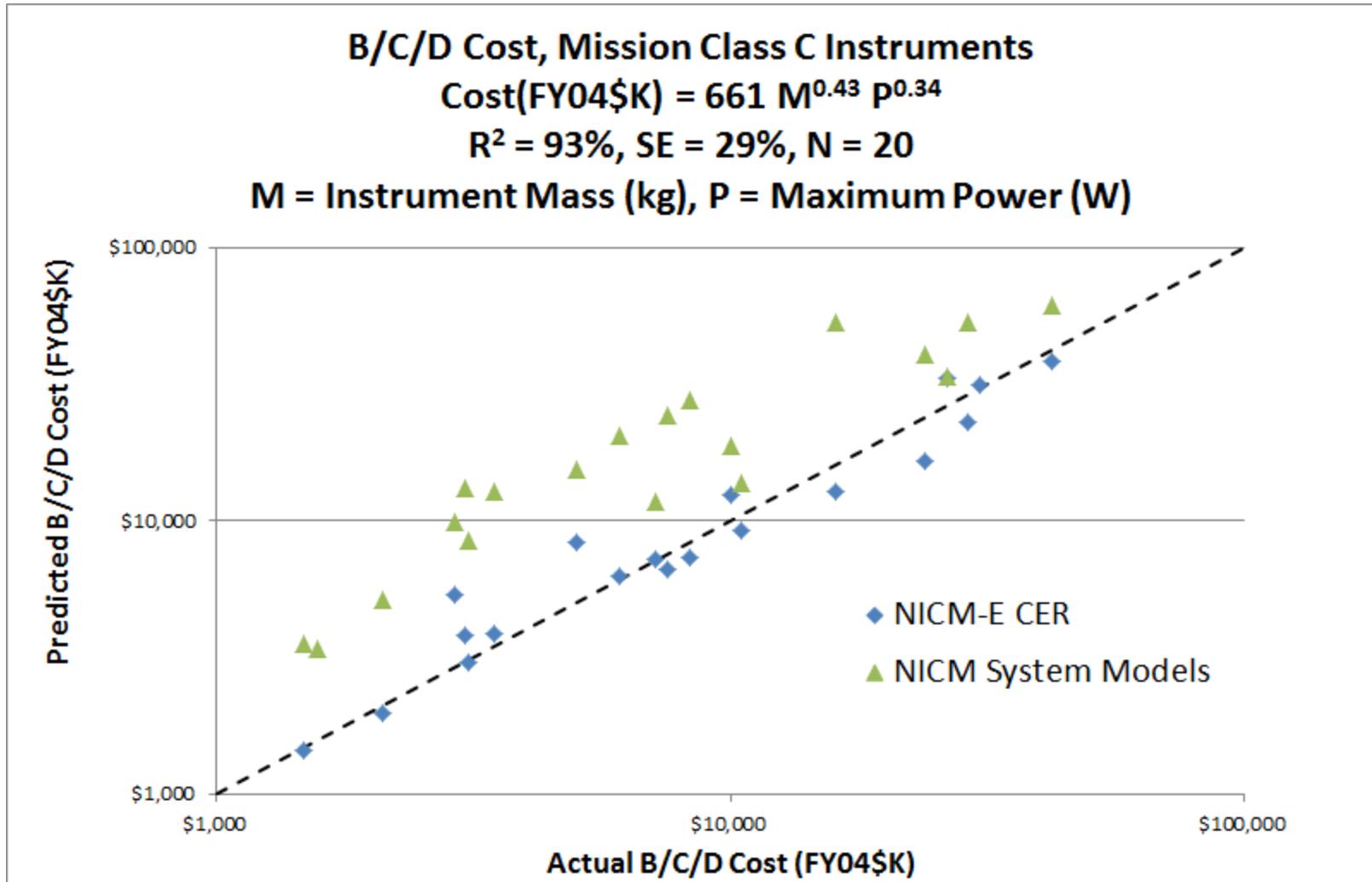


B/C/D Cost, Mission Class C Instruments

$$\text{Cost}(\text{FY04}\$K) = 661 M^{0.43} P^{0.34}$$

$R^2 = 93\%$, $SE = 29\%$, $N = 20$

M = Instrument Mass (kg), P = Maximum Power (W)



Analysis and Results



- As the statistical analysis indicates, the new CER explains 93% of the cost variation in Explorer-like mission instruments with the 3 required characteristics: Flew on a Class C mission, University led development, and significant inheritance.
- There was no discernible cost model difference between instrument types: Optical, Fields or Particles.
- As displayed on the figure, points on the dashed line have actual cost equal to the NICM-E CER cost estimate.
- Furthermore, when using the traditional NICM System Level CERs, all 20 instruments are predicted to have much higher costs than their actual costs.
- The analysis therefore indicates a need for this new CER for Explorer-like mission instruments.

Recommendations



- Use NICM-E to estimate cost for instruments that:
 - Will fly on a Class C mission AND
 - Where university or research foundations will lead and perform the majority of the instrument development (i.e. design through delivery) AND
 - Have significant inheritance
- If the instrument does not meet any of the above three criteria, use the traditional NICM System CERs.
- For instruments that meet some of the criteria but not all, run both NICM-E and the traditional NICM and interpolate.