A Parametric Approach to Mission Operations Costing

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Historically

- **Common practices**
  - Space Operations Cost Model (SOCM)
  - Percentage of Phase C/D costs
  - Analogies to similar missions adjusted for mission specifics

Objective

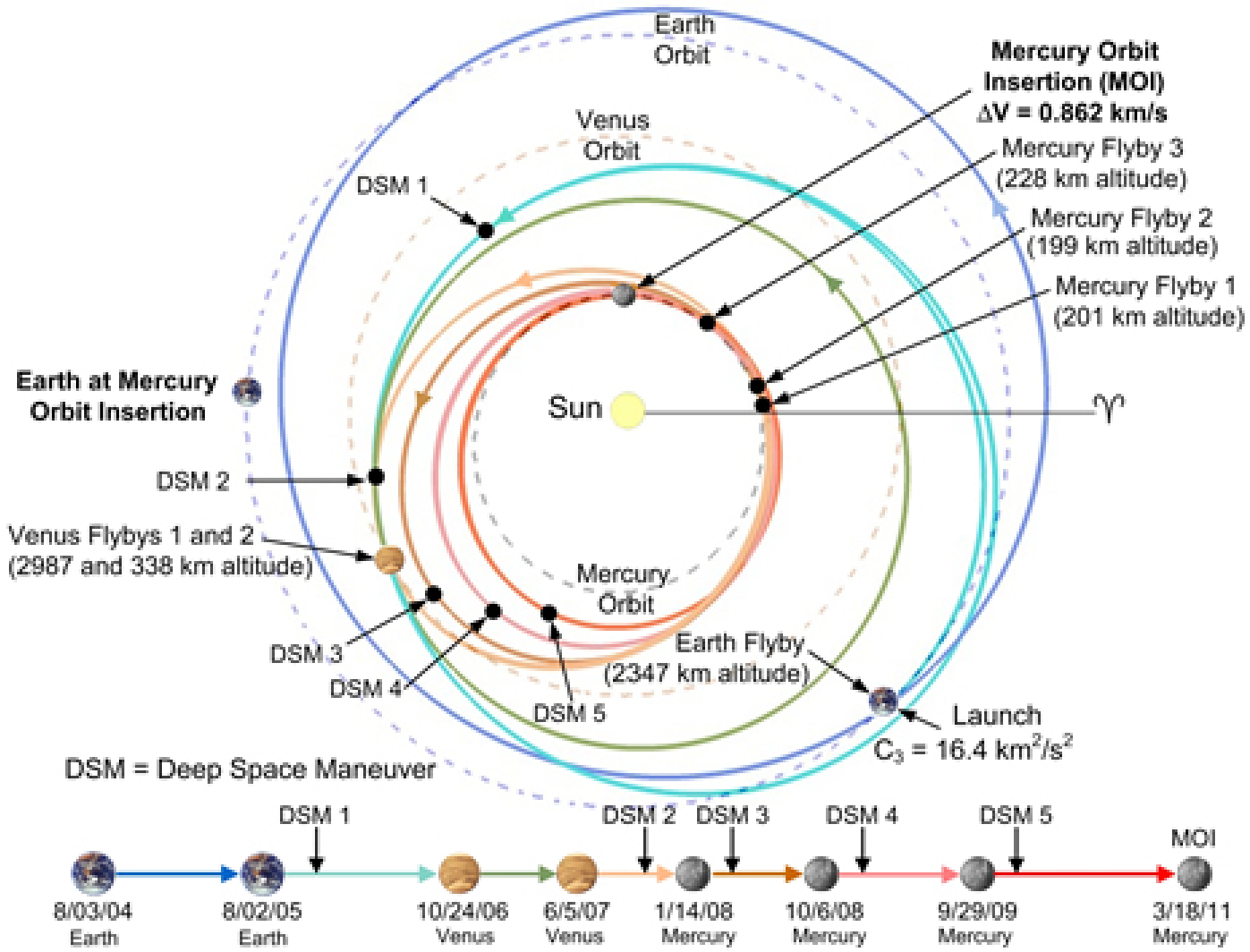
- **To develop a parametric model from APL's historical data that calculates the total cost of mission operations based on aspects of mission design such as**
  - Duration
  - Mission operation activity

Components of Mission Operations

- **Management**
- **Sustaining Engineering**
  - Hardware
  - Software – including updates
- **Mission Operators**
- **Scientists**
- **Planners**
- **Communications**
  - Deep Space Network (DSN)

Component costs vary by type and duration of activity

MESSENGER Mission Profile



Operation Activities

Type of Operation Activity	Description	Difference in Support
Hibernation	Spacecraft is in a safe state for long periods of time to reduce antenna time and staffing.	Periodic beacon signal and/or telemetry check-in are usually performed along with annual or semi-annual fully staffed and densely packed wake-up checkouts.
Gravity Boost	Produces a trajectory and/or speed change without the need for a large maneuver.	Additional coordination is required with Navigation and Mission Design teams.
Flyby	Used when orbit phase or permanent in-situ residence is not practical.	Scheduled backup antenna time opportunities, additional coordination is required with Navigation, Mission Design, and Science teams.
Rendezvous	This implies an approach phase, rendezvous time spent at an object, followed by a departure phase.	Staff is bumped up for reviews and days/weeks of activity.

Assumptions

- **Data from APL historical missions**
  - NEAR, MESSENGER, New Horizons, STEREO
- **Mission operations' costs start one month after launch**
  - Costs collected by month
  - Costs inflated using NASA inflation factors to FY15$
- **Total duration of non-cruise operation activities**
  - Start 3 months before event
  - End 3 months after event

Methodology

- **Hypothesis test for statistical significance**
  - Testing to see if the difference of each of DSM type was statistically significant
  - Normalized for overall mission cost by testing the percentage of total mission cost
- **Developed a CER based on findings**
  - Tested CER with historical data to verify model's effectiveness at predicting costs of mission operations

	Cruise				DSM			
Mission	**Mean**	**Variance**	**Observations**	**df**	**Mean**	**Variance**	**Observations**	**df**
NEAR	0.014	6.8E-05	47	46	0.016	2.1E-05	21	20
MESSENGER	0.010	7.0E-06	48	47	0.010	4.6E-06	49	48
STEREO	0.012	3.2E-05	65	64	0.036	7.1E-05	6	5
New Horizons	0.012	7.9E-05	73	72	0.019	1.5E-05	7	6

Findings & Results

Cost Delta from Standard Cruise per event FY15$M					
	Additional Month of Hibernation	Gravity Boosts	Flyby	Rendezvous	.5 yr Reduction of Total Duration
Labor & Procurements	$ 0.11	$ 1.39	$ 1.28	$ 0.96	$ 5.02
DSN	$ 0.01	$ 1.07	$ 1.92	$ 5.34	$ 0.53
Total	$ 0.12	$ 2.97	$ 3.20	$ 6.30	$ 5.55

- **Differences in average monthly cost from standard cruise were statistically significant**

Cost Estimate Relationship (CER)

- **The CER that drives the model is;**
  - (# of months of Hibernation * $788,105) + (# of months of Non DSM * $917,212) + (# of months Gravity Boosts * $1,523,330) + (# of months of Flybys * $1,987,324) + (# of months of Rendezvous * $3,001,355)

Possible Applications

- **Preliminary look at mission design feasibility**
- **Mission design trade studies**

Next Steps

- **Develop similar models for**
  - NSS operations
  - Standalone instrument operations
- **Further normalization for**
  - Extended mission operations
  - SOC/MOC development
  - Refurbishment of equipment

Questions?

Back-Up