Rocket Stage Optimization Results

Generated by Stage_Opt

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1 Introduction

This report presents the results of optimizing a multi-stage rocket using various optimization methods. The objective was to mazimize the payload mass fraction while satisfying the total delta-V requirement.

2 Input Assumptions

2.1 Global Parameters

Table 1: Global Parameters

Parameter	Value
Gravitational Acceleration (G_0)	$9.81\,\mathrm{m\,s^{-2}}$
Total ΔV Required	$0.0\,\mathrm{m\,s^{-1}}$

2.2 Stage Parameters

Table 2: Stage Parameters and Assumptions

Stage	ISP (s)	Mass Fraction (ϵ)
1	300	0.150
2	348	0.100

3 Optimization Methods

The following optimization methods were evaluated:

- SLSQP
- BASIN-HOPPING

- GA
- ADAPTIVE-GA
- DE
- PSO

4 Optimization Results

4.1 Performance Visualization

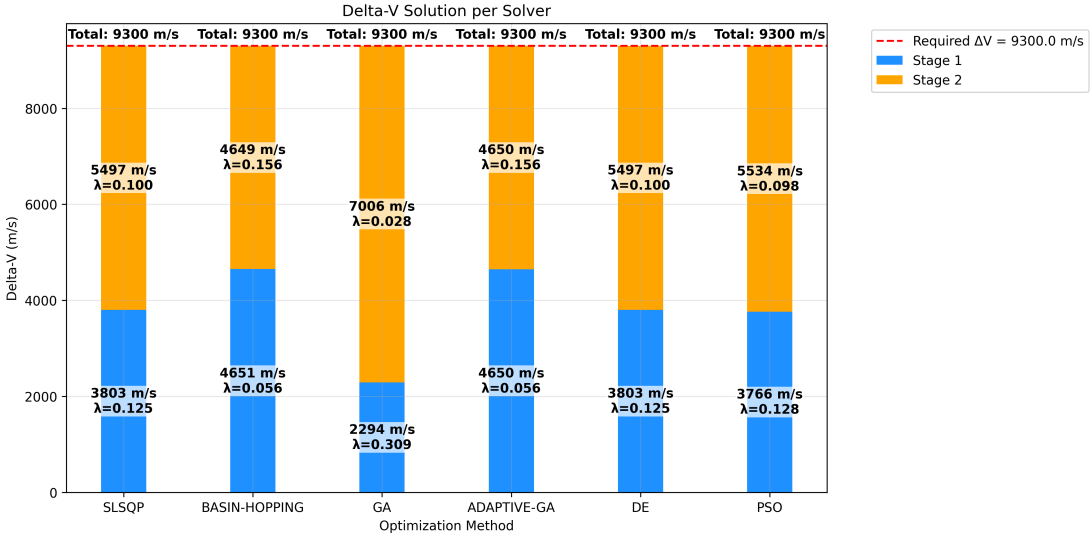

Figure 1: ΔV Distribution Across Stages

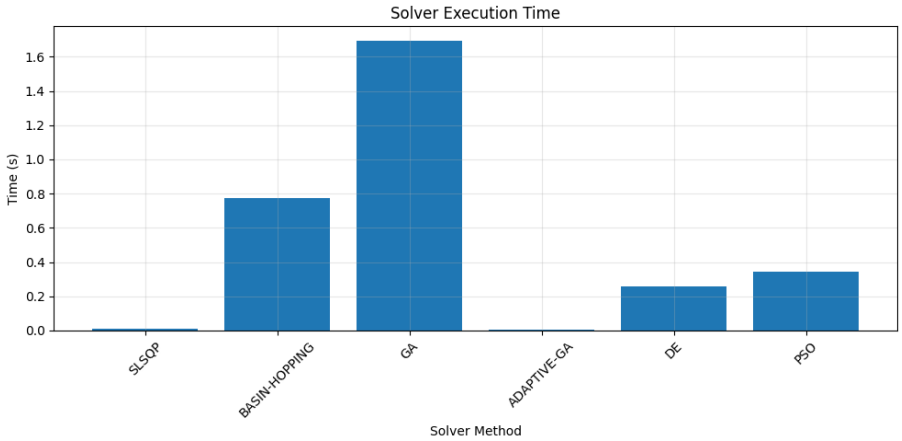

Figure 2: Solver Execution Time Comparison

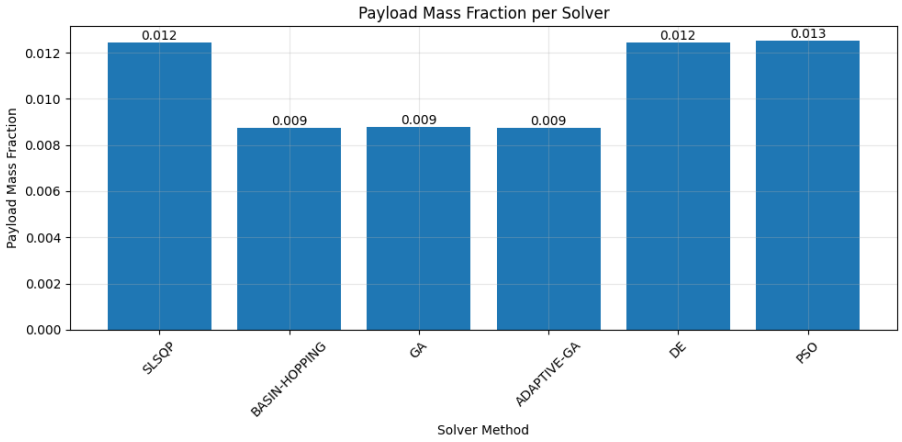

Figure 3: Payload Fraction Comparison

5 Final Results Summary

Table 3: Optimization Results Summary

Method	Payload Fraction	Error	Time (s)
PSO	0.0125	0.0000	0.34
SLSQP	0.0124	0.0000	0.01
DE	0.0124	0.0000	0.26
GA	0.0088	0.0000	1.69
ADAPTIVE-GA	0.0087	0.0000	0.01
BASIN-HOPPING	0.0087	0.0000	0.78

5.1 Stage-by-Stage Analysis

Table 4: Stage 1 Comparison Across Methods

Method	ΔV ($\mathrm{m\,s^{-1}}$)	Mass Ratio (λ)	Contribution (%)
PSO	3765.8	0.1282	40.5
SLSQP	3802.6	0.1247	40.9
DE	3802.6	0.1247	40.9
GA	2293.8	0.3087	24.7
ADAPTIVE-GA	4650.0	0.0560	50.0
BASIN-HOPPING	4651.0	0.0559	50.0

Table 5: Stage 2 Comparison Across Methods

Method	ΔV ($\mathrm{m\,s^{-1}}$)	Mass Ratio (λ)	Contribution (%)
PSO	5534.2	0.0977	59.5
SLSQP	5497.4	0.0998	59.1
DE	5497.4	0.0998	59.1
GA	7006.2	0.0284	75.3
ADAPTIVE-GA	4650.0	0.1561	50.0
BASIN-HOPPING	4649.0	0.1562	50.0

Table 6: Stage Distribution Summary

Method	Stage 1 (%)	Stage 2 (%)	Total λ
PSO	40.5	59.5	0.0125
SLSQP	40.9	59.1	0.0124
DE	40.9	59.1	0.0124
GA	24.7	75.3	0.0088
ADAPTIVE-GA	50.0	50.0	0.0087
BASIN-HOPPING	50.0	50.0	0.0087

Key Observations:

- Methods with even ΔV distribution ($\approx$ 50.0/50.0): BASIN-HOPPING, ADAPTIVE-GA
- Methods with uneven distribution: SLSQP, GA, DE, PSO
- Best Stage 1 mass ratio: GA
- Best Stage 2 mass ratio: BASIN-HOPPING