

# 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 maximize 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 ( $G_0$ )	$9.81 \text{ m s}^{-2}$
Total $\Delta V$ Required	$0.0 \text{ m s}^{-1}$

### 2.2 Stage Parameters

Table 2: Stage Parameters and Assumptions

Stage	ISP (s)	Mass Fraction ( $\epsilon$ )
1	300	0.060
2	348	0.040

## 3 Optimization Methods

The following optimization methods were evaluated:

- SLSQP
- BASIN-HOPPING

- GA
- ADAPTIVE-GA
- DE
- PSO

## 4 Optimization Results

### 4.1 Performance Visualization

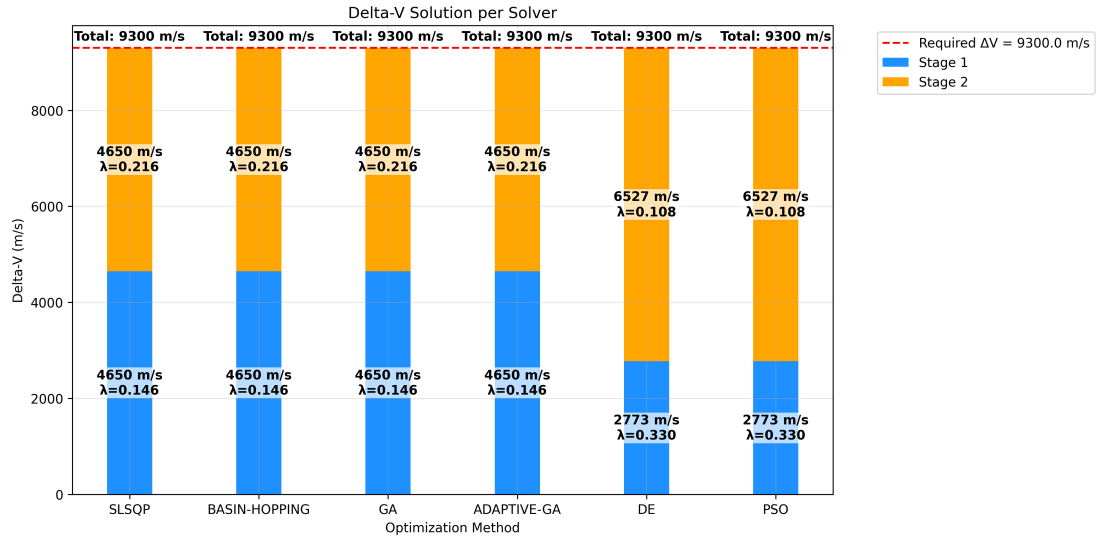


Figure 1:  $\Delta V$  Distribution Across Stages

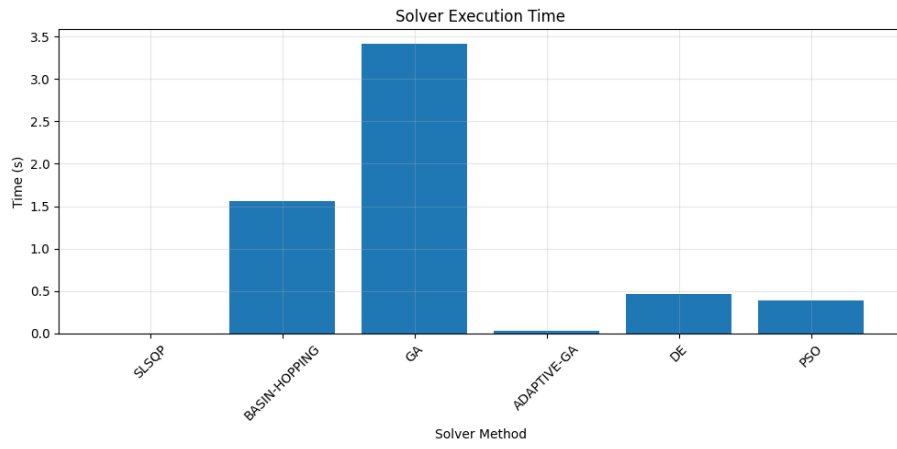


Figure 2: Solver Execution Time Comparison

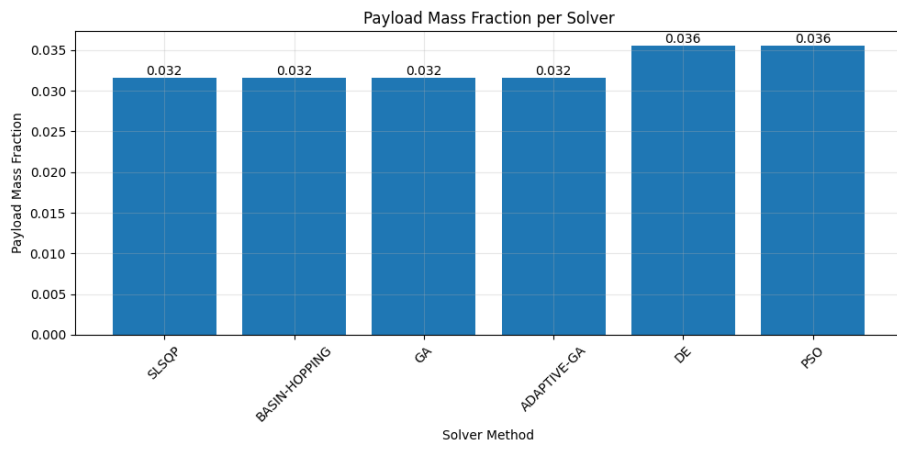


Figure 3: Payload Fraction Comparison

## 5 Final Results Summary

Table 3: Optimization Results Summary

Method	Payload Fraction	Error	Time (s)
SLSQP	0.0315	0.0000	0.00
BASIN-HOPPING	0.0315	0.0000	1.56
GA	0.0315	0.0000	3.41
ADAPTIVE-GA	0.0315	0.0000	0.04
DE	0.0355	0.0000	0.46
PSO	0.0355	0.0000	0.39

### 5.1 Stage-by-Stage Analysis

Table 4: Stage 1 Comparison Across Methods

Method	$\Delta V$ (m s <sup>-1</sup> )	Mass Ratio ( $\lambda$ )	Contribution (%)
SLSQP	4650.0	0.1460	50.0
BASIN-HOPPING	4650.0	0.1460	50.0
GA	4650.0	0.1460	50.0
ADAPTIVE-GA	4650.0	0.1460	50.0
DE	2772.9	0.3298	29.8
PSO	2773.0	0.3298	29.8

Table 5: Stage 2 Comparison Across Methods

Method	$\Delta V$ (m s <sup>-1</sup> )	Mass Ratio ( $\lambda$ )	Contribution (%)
SLSQP	4650.0	0.2161	50.0
BASIN-HOPPING	4650.0	0.2161	50.0
GA	4650.0	0.2161	50.0
ADAPTIVE-GA	4650.0	0.2161	50.0
DE	6527.1	0.1078	70.2
PSO	6527.0	0.1078	70.2

Table 6: Stage Distribution Summary

Method	Stage 1 (%)	Stage 2 (%)	Total $\lambda$
SLSQP	50.0	50.0	0.0315
BASIN-HOPPING	50.0	50.0	0.0315
GA	50.0	50.0	0.0315
ADAPTIVE-GA	50.0	50.0	0.0315
DE	29.8	70.2	0.0355
PSO	29.8	70.2	0.0355

**Key Observations:**

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