JPL

STARLIGHT

IPAO Independent Cost Estimate
StarLight Project Summary

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Project Overview

STARLIGHT

Key Mission Features

- **Formation Space Optical Interferometer**
  - **Two S/C flying in formation**
  - **40 - 600m S/C separation**
  - **30 - 125m interferometry baseline**
- **Launch June 2006**
- **Heliocentric, Earth leading orbit**
- **Delta 7925**
- **6-month baseline mission**

Technology

- Separated spacecraft optical interferometry
  - Metrology system measures changes to 11 nm, delay line control to 35 nm
  - Spectral range 600 to 1000 nm
  - Fringe detection on 5th magnitude stars
- Precision formation flying
  - Relative position control +/- 10 cm
  - Relative attitude control +/- 4 arcmin
- Precision formation flight and long baseline, visible wavelength interferometry

StarLight Technologies

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Technology		Validation: Near-Term Mission			Need: Future Mission						
		StarLight	Keck	SIM	TPF Interferometer	TPF Hyper Telescope	MAXIM Pathfinder	SPECS	Stellar Imager	Life Finder
Formation Flying	Architecture suitable for > 3 S/C case	✔								
	RF Sensor Technology--~1 cm, 1 arcmin, 4pi	✔								
	FF Sensor validation of range & angle	✔								
Formation Precision Measurement	Long-range linear laser metrology--10 nm	✔	✔	✔						
	Angular laser metrology (arcsecond)	✔								
	Angular starlight metrology (arcsecond)	✔								
	End-to-end system performance validation	✔								
Interferometry on Free Flyers	Variable baseline	✔								
	Mid-IR detectors		✔							
	Broadband cryogenic nulling		✔							
	Fringe detection & tracking (w/ validation)	✔	✔	✔						
	FTS Mode (Fourier Transform Spectrometer)									
	Rejection of reflection/emission from S/C	✔								

F ght Sys em Launch Conf gura on

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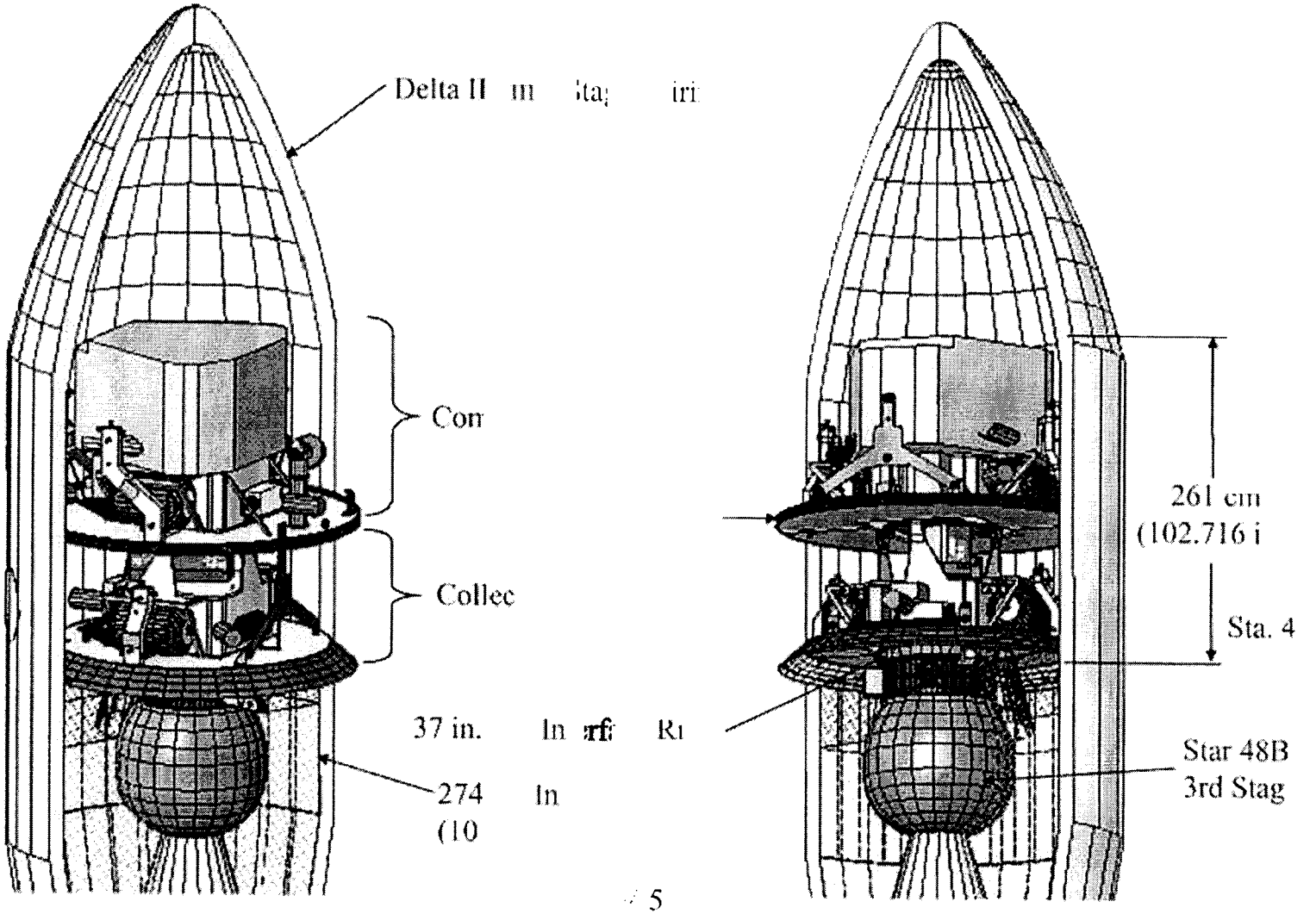
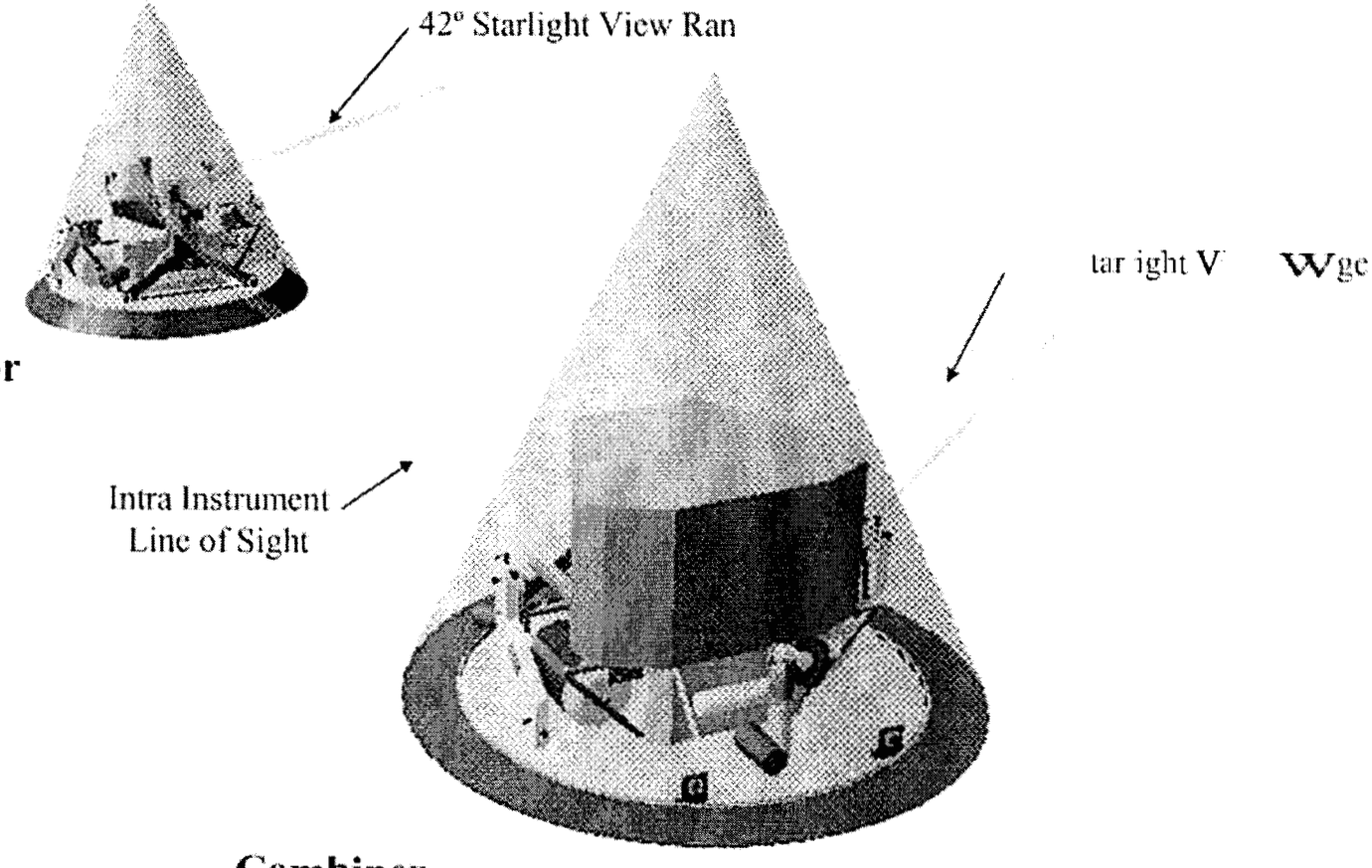


Flight System Separated Configuration



StarLight Project Schedule

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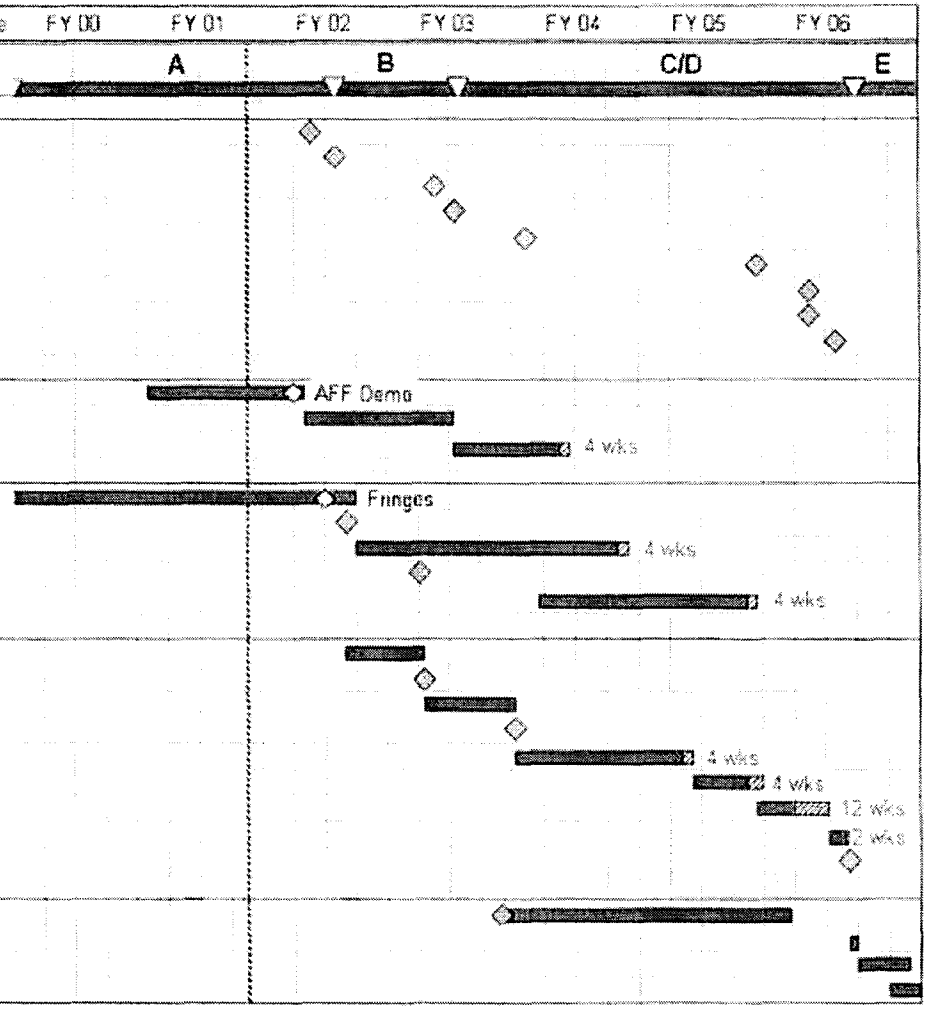
Activity Name	Start Date	Finish Date
Project Phases...	10/2/99	4/30/02
Project Reviews		
MDR/SRR	2/18/02	
Initial Confirmation Review	5/1/02	
PDR	2/17/03	
Confirmation Review	4/21/03	
CDR	11/11/03	
Environmental Test Readiness Review	9/13/05	
Pre-Ship Review	2/13/06	
Mission Operations Readiness Review	2/13/06	
Launch Readiness Review	5/1/06	
AFF Sensor		
Prototype Development	11/1/00	2/1/02
Tech/EM Development	2/1/02	4/15/03
Flight Development	4/16/03	3/16/04
Interferometer		
FIT-1	10/2/99	7/1/02
PDR	6/4/02	
Subsystem Development	7/1/02	9/1/04
CDR	1/7/03	
Interferometer Integration & Test	12/20/03	9/13/05
Flight System		
Preliminary Design	6/1/02	1/21/03
PDR	1/21/03	
Detailed Design	1/21/03	10/11/03
CDR	10/11/03	
Subsystem Fab and Assembly	10/11/03	3/8/05
Bus/Constellation I&T	3/8/05	9/12/05
Flight System I&T	9/13/05	4/8/06
Launch Site Ops	4/9/06	6/5/06
Launch	6/6/06	
Missions Operations		
GDS Deliveries	9/1/03	12/22/05
Checkout	6/6/06	6/30/06
Operations	7/1/06	11/30/06
Data Analysis	10/1/06	12/28/06



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StarL ght Status

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Pro ec n Pha A work ng on

- Formation F y ng and In rferom ter techno ogy d v opm n and y tem d mon: tra on
- Conc ptua d gn tr d tud
- Pro c P an and Requir m :n: d fini on

M on Defin: ion Review Sy em R. qu.r n: n Rev ew n a e February 2002

n a Confirma on Rev ew a d Pha B art n May 2002

StarLight Project Cost Estimate

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- **Grass roots estimate completed at WBS Level 5**
- Cost and schedule estimates performed by the Cognizant Engineers and PEMs, input verified and agreed to by the line organizations
- **Workforce requirements have been reviewed with the line organizations**
- **Ball Aerospace spacecraft bus estimate at WBS Level 5**
  - **Ball Phase C/D contract has not been negotiated**
- StarLight cost plan reviewed extensively by the project, independent peers and the line organizations
- Total project cost reviewed with Gavin, Simmons, Devirian
- **Aerospace Independent Cost Estimate within 5% on StarLight grass roots estimate**

StarLight Budget Comparison

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	FY01 POP Submit	Current Estimate
Project Phase B Start	October 2002	May 2002
Launch	June 2006	June 2006
B/C/D Cost in FY01$	$224M	$242M
Launch Vehicle in FY01$	$66M	$66M
B/C/D Total in FY01$	$290M	$308M
Phase A-E Cost in RY01$ (incl. LV)	$390M	$390M

Changes to B/C/D FY01$ Cost Accounting

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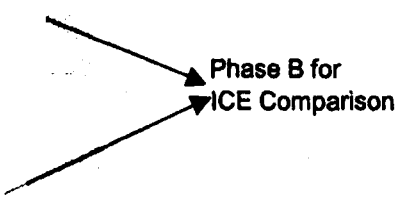
- Phase B start moved from October 2002 to April 2002
  - Moved Confirmation Assessment and Initial Confirmation Review out of phase with FY02 POP cycle

    Phase B of 1 year more realistic

    No change to runout cost
- Interferometer and AFF Phase B start begins in Project Phase A: Identified separately for comparison to IPAO ICE

Phase A Project	44
Interferometer Phase B Work done in Project Phase A	3
AFF Phase B Work done in Project Phase A	3
Phase B Project	39



Project/IPAO Budget Comparison

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Cost Element (FY01$M)	Original IPAO	Expected JPL	Expected IPAO	Notes
Phase A Total (minus AFF and IF Phase B work in Phase A)	38	38	38	Passthrough
Program Management	2	9	2	
Systems Engineering	3	1	3	
Science	20	0	0	
Instrument	66	54	60	Working software and metrology
Spacecraft	132	111	128	Working software and fault protection
Ground System	10	11	11	Passthrough
Outreach	2	1	1	Passthrough
Mission Assurance	0	6	0	
CalTech Fee	3	3	3	IPAO will use 1.4%
Phase B/C/D Development	238	196	208	
Launch Costs	74	66	66	Passthrough
Reserves on Development	83	48	62	Placeholder
Inflation	0	4	0	
Reserves on Launch Costs	7	0	0	LSTO not to exceed
Phase B/C/D Total	403	314	336	
Operations	5	6	6	Passthrough
Reserve	1	2	2	Passthrough
Phase E Total	6	8	8	
Total Life Cycle	447	360	382	

Percentage Difference (IPAO-JPL)/JPL 6%

IPAO Areas of Concern

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- Format on Flying h: n v r b n don b for
- M tro ogy alw y co mor han e timated/ a er d ode f tim ue
- Softw r n v r co ed right
- No nd p nd n A e men ha o be eve our guy know wha h y ar doing

Summary

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- StarLight is a *near-term* flight demonstration of advanced technologies required many future astrophysics missions

- **StarLight can be successfully completed for the FY01POP implementation budget and schedule**
  - **StarLight has completed a thorough Phase A study producing well defined requirements and architecture**
  - **Cost and schedule estimates were produced by a very capable team and commitments are in place**

    The plan has been extensively reviewed

- **The IPAO Independent Cost Estimate and the Aerospace cost Estimate are both well within 15% of the StarLight Cost Estimate**
  - **IPAO: 6%**
  - Aerospace: 5%