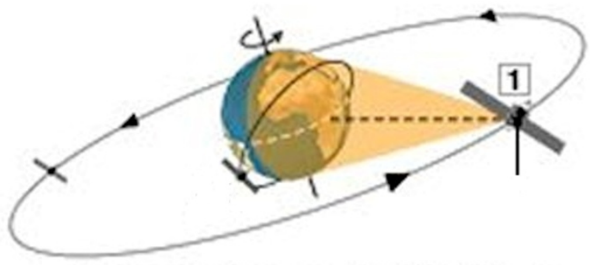
Mission Architecture Concepts for Time-Resolved Science

Option 1: NASA GEO spacecraft

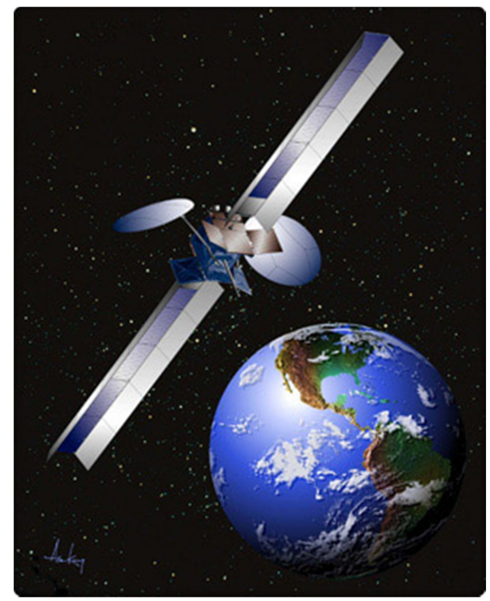


Dedicated, long life GEO spacecraft
Orbit 35,786 km stationary orbit above Earth
Examples: GOES, TDRSS

Option 2: LEO Swarm

Multiple inter-calibrated copies
6-10 spacecraft and launches to Leo
Examples: IRIDIUM, GPS

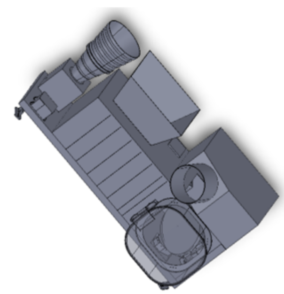
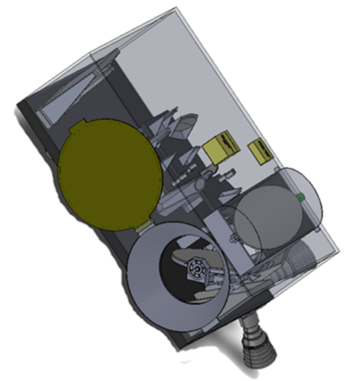
Option 3: NASA payload hosted on commercial GEO spacecraft



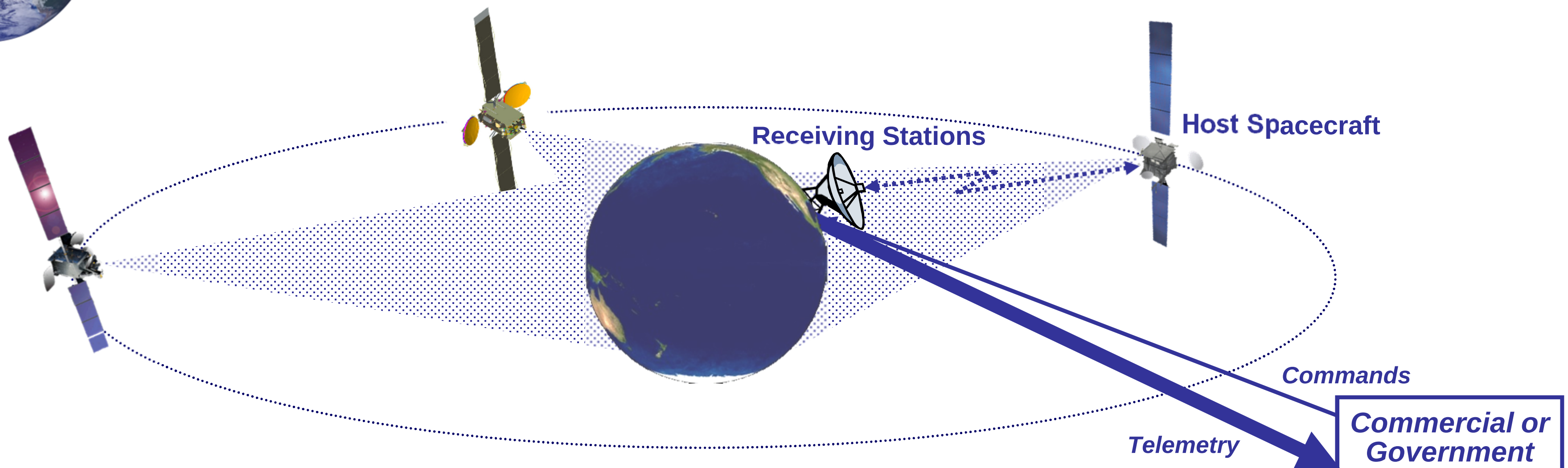
Frequent launches to GEO
Excess capacity (mass and power)
Examples: FAA's WAAS, Air Force CHIRP

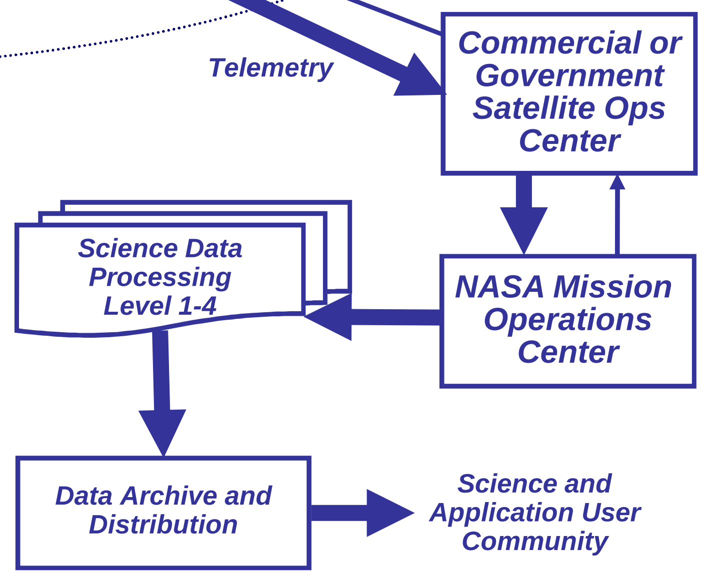
GEO-CAPE Planning Payload

The GEO-CAPE planning payload is representative of the instrumentation that could accomplish the science measurements defined in the STMs

	Small	Medium	Large
GEO-CAPE Notional Planning Payload Instrumentation	 CISR	 GeoMAC	 CEDI
Science	Atmospheric Composition		Coastal Ecosystems
Instrument Concept	Gas-Filter Correlation Radiometer	UV-Vis Spectrometer	UV-Vis-NIR Spectrometer
Spectral Range (µm)	2.3 and 4.67	0.30 to 0.48	0.34 to 0.90 1.225 to 2.160
Size: L x W x H (m)	0.75 x 0.4 x 0.5	1.7 x 0.8 x 0.9	2.1 x 0.95 x 2.8
CBE Mass (kg)	45	140	621
CBE Power (W)	120	233	392
Data Rate (Mbps)	40	16.4	88.4

Hosted Payload Concept of Operations





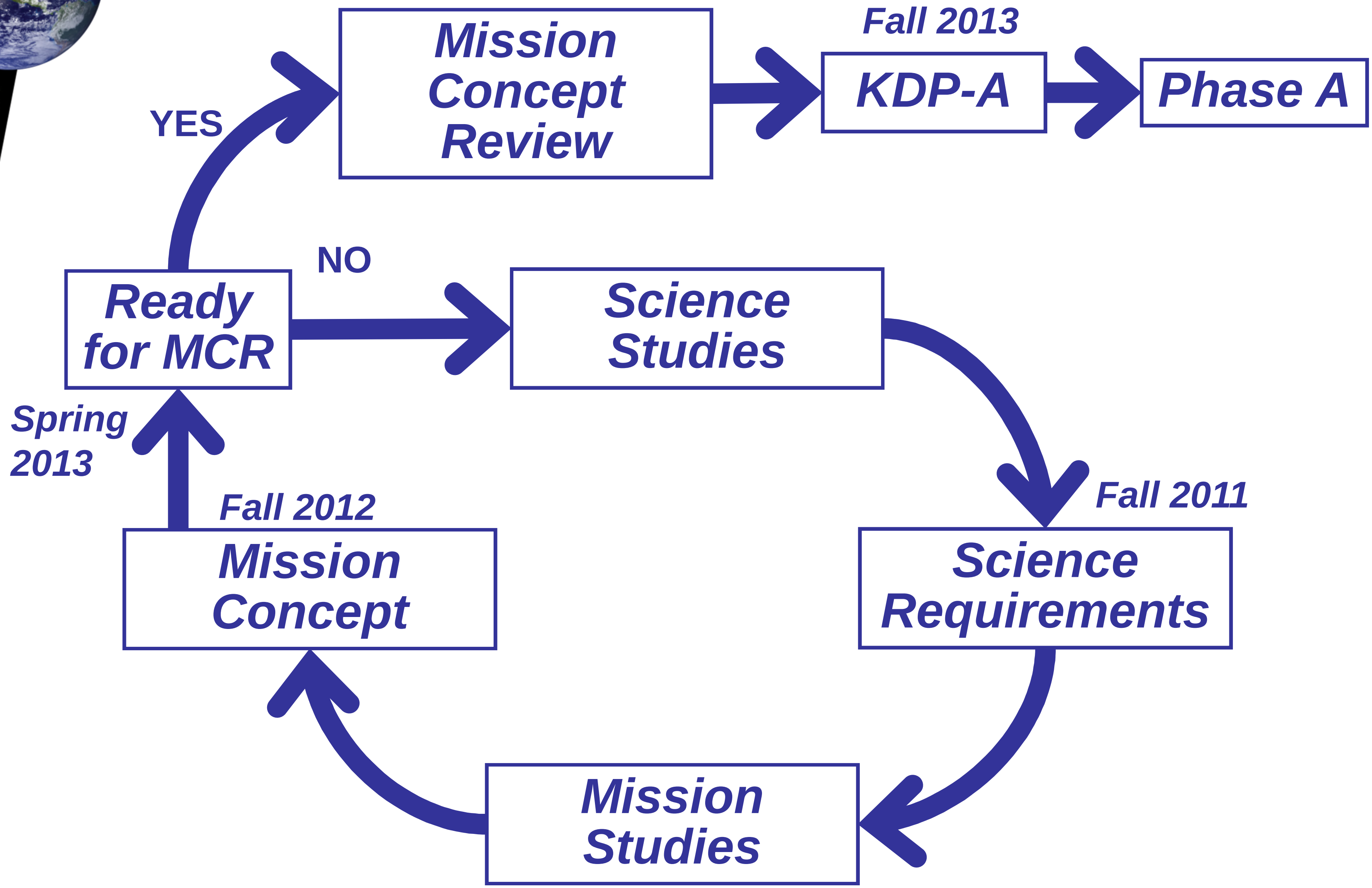
- Geostationary orbit provides the option for continuous downlink because the satellite remains in the same fixed location over the ground station for the life of the mission
  - *Minimal data latency could support near real time applications such as chemical weather forecasting*
- The hosted payload approach provides the option to purchase telemetry services from the satellite operator (if it is a comsat)
  - *Continuous direct data transfer from instrument to host comsat transponders (bent pipe downlink)*
- NASA operates science processing, archive, and distribution

Mission Implementation ROM Cost Estimates

WBS	PROJECT ELEMENT	Cost (FY'11 $M)				
		Small	Medium	Large	HPL Total	DM Total[2]
01	Project Management	7	13	30	50	47
02	Mission Systems Engineering	4	13	30	48	47
03	Safety & Mission Assurance	2	8	19	29	29
04	Science	8	14	34	57	57
05	Science Payload	42	90	239	371	421
06	Spacecraft	0	0	0	0	403
07	Mission Operations	6	15	39	61	97
09	Ground Data System	2	6	16	23	38
10	Systems I&T	5	0	0	5	32
	Hosted Payload Related Costs[3]	35	68	142	246	0
	Subtotal without Reserves	112	227	550	889	1,173
	Reserves	34	69	166	268	354
	Subtotal with Reserves	146	296	716	1,158	1,527
08	Launch Vehicle / Services	0	0	0	0	313
11	Education and Public Outreach	2	2	4	7	7
	Total Life-Cycle Cost (FY'11 $M)	147	298	720	1,165	1,846

The hosted payload, phased implementation mission architecture reduces mission cost and risk, and delivers science data sooner

Mission Concept Development



GEO-CAPE MCR Preparations

- Establish mission performance metrics (success criteria, aka measures of effectiveness – MOEs and associated Key Performance Parameters - KPPs)

- Conduct trade studies
  - – Science requirements, to identify the significant cost vs. performance parameters
  - – Mission risk (identify cost vs. reliability drivers)
  - – Technology alternatives
  - – Acquisition strategy
  - – Mission operations approach
  - – Data processing and distribution approach
  - – Access to space (launch vehicle selection; co manifest; etc.)

- Develop / document the mission science requirements (STM and Level 1 req's)

- Explore a full range of mission implementation options to:
  - – Define mission concepts that meet the Level 1 requirements
  - – Investigate instrument and mission design and development alternatives, including make/buy decisions and different mission operations approaches
  - – Identify the optimum range of cost, schedule, and capability that will maximize the science/cost ratio across the entire Decadal Survey flight program
  - – Identify needed technologies and maturation plans
  - – Identify potential partnerships with non-NASA organizations

- Draft a mission concept report that shows the mission is ready to start Phase A

NPR 7123 Requirements for MCR*

Mission Concept Review (MCR)

Entrance Criteria	Success Criteria
1. Mission goals and objectives.	1. The need for the mission has been clearly identified.
2. Analysis of alternative concepts to show at least one is feasible.	2. Mission objectives are clearly defined and stated and are unambiguous and internally consistent.
3. Concept of operations.	3. The preliminary set of requirements satisfactorily provides a system that will meet the mission objectives.
4. Preliminary mission descope options.	4. The concept evaluation criteria to be used in candidate systems evaluation have been identified and prioritized.
5. Preliminary risk assessment, including technologies and associated risk management/mitigation strategies and options.	5. The mission is feasible. A solution has been identified that is technically feasible. A rough cost estimate is within an acceptable cost range.
6. Conceptual test and evaluation strategy.	6. The cost and schedule estimates are credible.
7. Preliminary technical plans to achieve next phase.	7. An updated technical search was done to identify existing assets or products that could satisfy the mission or parts of the mission.
8. Defined Measures of Effectiveness (MOEs) and Measures of Performance(MOPs).	8. Technical planning is sufficient to proceed to the next phase.
9. Conceptual life-cycle support strategies (logistics, manufacturing, and operation).	9. Risk and mitigation strategies have been identified and are acceptable based on technical risk assessments.

* NPR 7120.005D page 19 points to NPR 7123.1A – Appendix G3

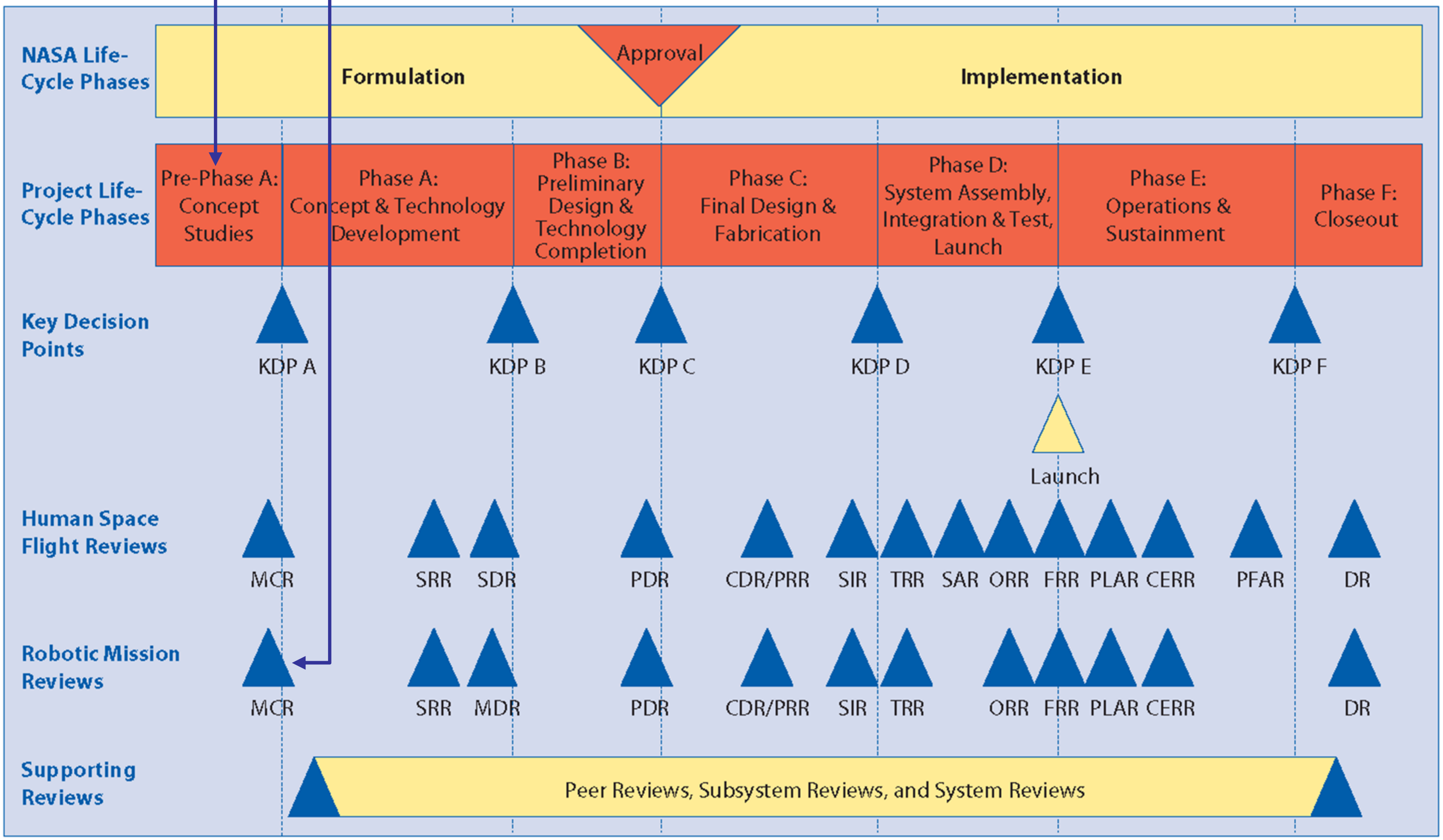
Strawman GEO-CAPE Study Schedule

ID	Task	Notes
1	**GEO-CAPE Community Workshop**	
2	**Science Requirements**	
3	Science partnership discussions	Partnership agreements with NOAA, EPA, international organizations / agencies
4	Baseline science requirements	Scientific requirements that must be achieved to fully satisfy baseline science objectives
5	Simultaneous observations req.	Degree that ocean and atmosphere observations must be simultaneous / overlap
6	Observing scenario	Definition of observation pattern / pointing scenario over the science field of regard
7	Science descope options	Priority of science requirements; partial requirements fulfillment acceptability
8	Threshold science requirements	Minimum requirements which scientifically justifies performing the mission
9	STMs / L1 science req's published	Draft Level 1 science requirements, measures of effectiveness (MOEs, KPPs)
10	**HPL Implementation Assessment**	
11	Government HPL	Assessment of GOES, TDRSS, DoD hosting opportunities
12	Commercial HPL	Updated data on commercial hosting opportunities and costs
13	HPL assessment report	Hosting accommodations and opportunities (LRDs, payload mass, size, geometry, etc.)
14	**Instrument Design Studies**	
15	Instrument line-of-sight pointing study	Instrument line-of-sight pointing capability trade-offs, design concepts, costs
16	GeoMAC instrument study	GeoMAC instrument characteristics, capabilities, cost; cloud detection?
17	PanFTS instrument study	PanFTS instrument characteristics, capabilities, cost
18	CEDI instrument refinement study	CEDI design refinement (atmospheric correction, size minimization, etc.)
19	Planning payload instrument study report	Summary descriptions of instrument concepts (characteristics, capabilities, costs)
20	**TRL Assessment**	
21	ESTO TRL assessment	Technical readiness and risks assessment of GEO-CAPE instrument concepts
22	TRL assessment report	Technology readiness and maturation plan
23	**Mission Design Studies**	
24	Acquisition strategy	Preliminary acquisition strategies for all major procurements
25	Baseline mission study	Mission capability that fulfills baseline science objectives (dedicated, distributed)
26	Mission descope options	Reductions in mission capability / cost from baseline science down to threshold
27	Mission study report	Mission architecture and system concept(s), cost and schedule, risks
28	**Mission Concept Review**	
29	Draft level 1 requirements document	Science objectives, instrument summaries, mission success criteria, etc.
30	Mission concept report	Mission architecture, system concept(s), acquisition approach, cost, schedule, risks
31	Preliminary integrated baseline	Project WBS, integrated milestone schedule, lifecycle cost, risk assessment, etc.
32	Preliminary formulation authorization document (FAD)	Mission purpose, authority, goals & objectives, participants, funding, reviews
33	Mission concept review (MCR)	The MCR affirms the mission need and examines the proposed mission's objectives and the concept for meeting those objectives
34	**Key Decision Point A (KDP-A)**	NASA approval to begin formulation of the GEO-CAPE mission

NASA Mission Life-Cycle*

GEO-CAPE is here

Need to be ready for a Mission Concept Review in FY'13



* Source: NASA/SP-6105 Systems Engineering Handbook, page 20

NPR 7123 Requirements for SSR*

<table>
<tr><th colspan="2">System Requirements Review (SSR)</th></tr>
<tr><th>Entrance Criteria</th><th>Success Criteria</th></tr>
<tr><td>1. Successful completion of the MCR and responses made to all MCR Requests for Actions (RFAs) and Review Item Discrepancies (RIDs).
2. A preliminary SRR agenda, success criteria, and charge to the board have been agreed to by the technical team, project manager, and review chair prior to the SRR.
3. The following technical products for hardware and software system elements are available to the cognizant participants prior to the review:
a. system requirements document;
b. system software functionality description;
c. updated concept of operations;
d. updated mission requirements, if applicable;
e. baselined SE Mgmt. Plan;
f. risk management plan;
g. preliminary system requirements allocation to the next lower level system;
h. updated cost estimate;
i. Technology Development Maturity Assessment Plan;
j. updated risk assessment and mitigations (including PRA as applicable).
k. logistics documentation (e.g., preliminary maintenance plan);
l. preliminary human rating plan, if applicable;
m. seven more incl. s/w, config. mgmt, etc.</td><td>1. The project utilizes a sound process for the allocation and control of requirements throughout all levels, and a plan has been defined to complete the definition activity within schedule constraints.
2. Requirements definition is complete with respect to top-level mission and science requirements, and interfaces with external entities and between major internal elements have been defined.
3. Requirements allocation and flow down of key driving requirements have been defined down to subsystems.
4. Preliminary approaches have been determined for how requirements will be verified and validated down to the subsystem level.
5. Major risks have been identified and technically assessed, and viable mitigation strategies have been defined.</td></tr>
</table>

* NPR 7120.005D page 19 points to NPR 7123.1A – Appendix G4