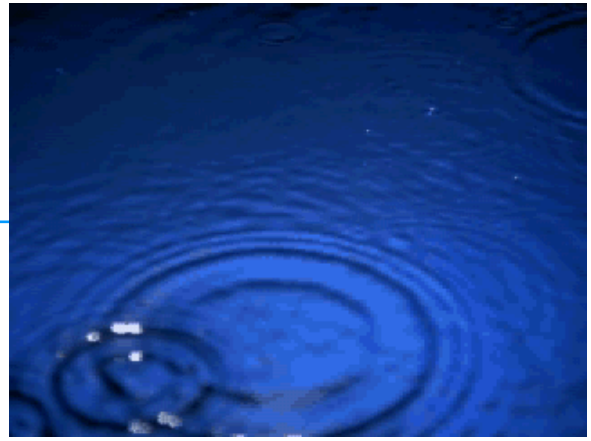
Global Precipitation Measurement

System Requirements Review
System Engineering Process



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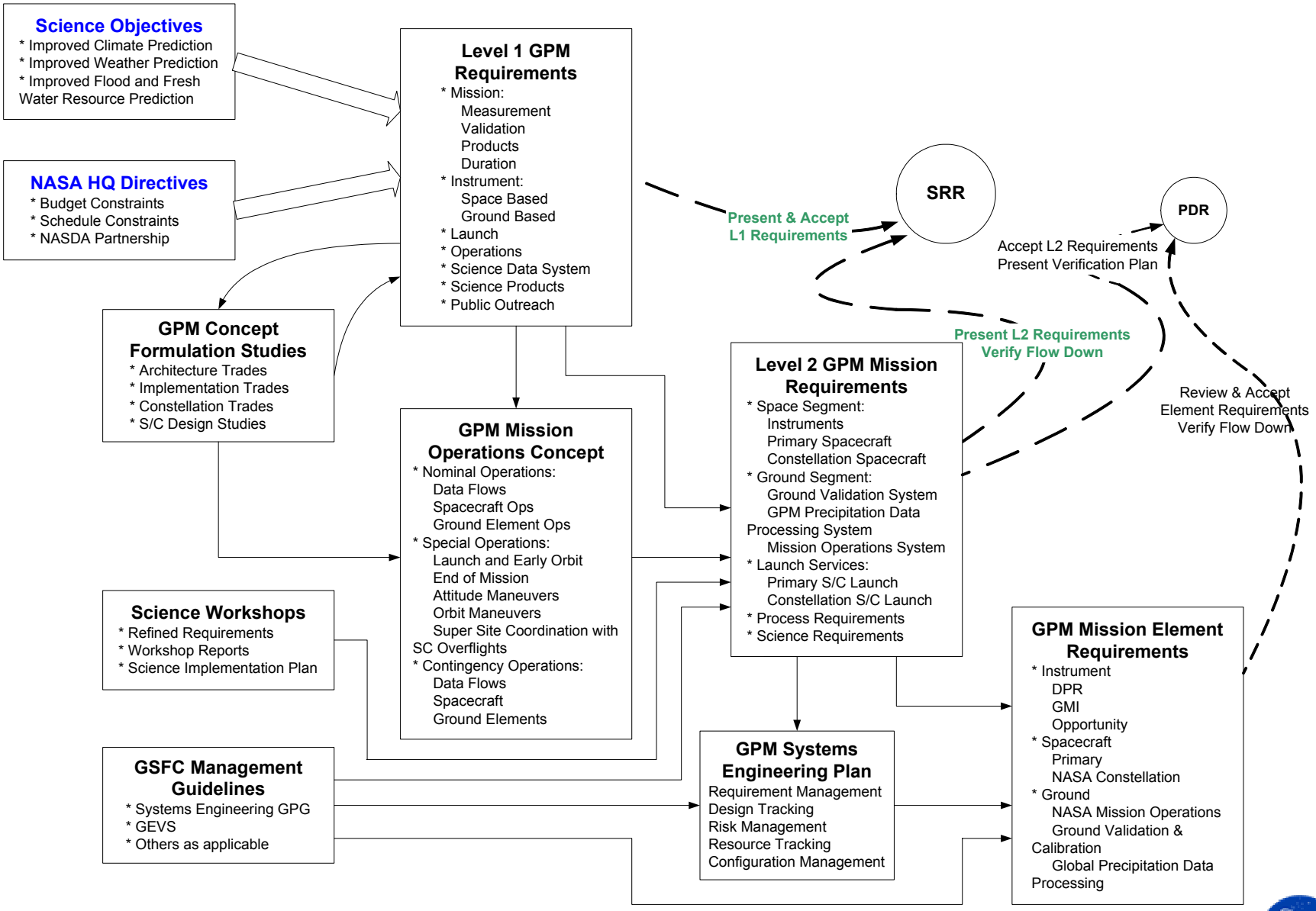
Overview

- *Introduction*
- *Requirements Development & Flow Down*
- *SEMP Process*
- *Implementation in SLATE*
- *Risk Management*
- *Risk Process*
- *Systems Engineering Schedule*
- *Systems Engineering Status*

Requirements Development & Flow Down



SEMP Overview

- ***System Engineering Management Plan (GSFC 420.2-02-001-01)***
  - *Signed by Project Formulation Manager, Mission System Engineer, GSFC Chief System Engineer*
  - *Describes System Engineering for GPM*
  - *Current version only covers formulation, next release (prior to PDR) to cover implementation.*
- ***Process described by phase of development and specific activities***
  - *(See next chart Exhibit 3-1)*
- ***Each phase detailed with entry criteria, exit criteria, inputs, outputs, and tasks***
  - *(See Exhibit 4-1)*
- ***Each phase describes responsibilities for element engineers.***
  - *(See Exhibit 4-4)*

SEMP Process

		Formulation		Implementation		Operations
Control Gates	Mission	SRR	PDR	CDR		
	Integrated Ops				MOR, FOR, ORR	
	Primary Spacecraft				Pre-Env, Pre-Ship	
Systems Engineering Activities	Concept Development	- Baseline Operations Concept	- Detailed Element Concept Development	- Detailed Subsystem Concept Development		
	Requirements Development	- Mission L2 Reqs Development - Preliminary Resource Budgets - Preliminary Element Interface Descriptions	- Element L3 Reqs Development - Subsystem L4 Reqs Development - Baseline Resource Budgets - Subsystem ICDs	- Resource Budgets	- Define Configuration Requirements/ Data Dictionary	- Operational Feedback to Requirements
	Architecture Design	- Functional Element Architecture	- Functional Subsystem Architecture	- Physical Component Architecture - Physical Schematic Architecture		
	Build	- Consider during requirements development	- Identification of long lead production items	- Prototype and demonstration - Initiate acquisition for long lead production items	- Develop and integrate components	- As Built Documentation
	Integration	- Consider I&T during requirements development	- Preliminary I&T Plan	- I&T Plan	- Execute I&T for Prime S/C, Ground Systems, GVS, and SDPS	- Assess I&T Process
	Validation & Verification	- Define Verification Strategy	- Validate L2 Requirements (Is the correct system being designed?) - Baseline Verification Method/Plan	- I&T Plan - Validate L3/L4 Requirements	- Verify System Against Requirements (Has the correct system been built?) - Track Resource Budgets	- Validate L1 Requirements (Is the mission successful?) - Verify Models vs. Operational Data - Resource Budget Feedback
	Operations & Maintenance	- Consider O&M during requirements development	- Preliminary Operations Plan	- Mission Operations Plan - Draft Procedures - Contingency Plans	- Simulation Support - Procedure Finalization and Validation	- Operations - Anomaly Resolution - Data Processing and Delivery
Enabling Activities	Trade Studies	- Operations Concept Trades - Element Requirements Trades - Architecture Trades	- Subsystem Requirements Trades - Architecture Trades	- Operations Architecture Trades		
	Peer Reviews (Mission SE and Element)	- Support System Definition and Team definition	- Support Component-level Decision	- Focus on Operations and Mission Integration	- Focus on Prime S/C I&T - Operations Readiness - Ground Validation Site Performance	- Assess Process
	Communications	- Define engineering teams - Establish Toolset for Req, Arch, Knowledge Capture, Mod & Sim	- Focus on element requirements, architecture, subsystem interfaces - SLATE Prime for Req and Arch	- Component definition and detailed design	- Focus on Systems Integration	- Assess Process
Engineering Management and Control	Risk Management	- Define Risk Management Process - Define Risk Assessment Process - Identify Mission, Element Level Risks	- Identify Subsystem Level Risks - Define Mitigation Techniques - Track Risks and Mitigation	- Identify Component Level Risks - Track Risks and Mitigation - Retire Risks	- Retire Risks	- Track Operational Risks
	Reliability Assessment	- Consider Reliability during requirements development	- Preliminary Reliability assessment at component level	- Validate against reliability requirements	- Test against reliability requirements	- Verify Reliability Models against Operational Data
	Configuration Management	- Define CM Process - Establish CM in Requirements and Trades	- Establish CM in Architecture and Reliability	- Establish CM in I&T processes	- Establish CM in Operations processes	- Assess Process

Exhibit 3-1. GPM Systems Engineering Process Overview

SEMP Process Pre-SRR

	Mission Integrated Ops Primary Spacecraft	SRR
Entry Criteria - Code Y Approval of Advanced Studies - Formulation Guidance to Proceed	Concept Development	- Baseline Operations Concept
	Requirements Development	- Mission L2 Reqs Development - Preliminary Resource Budgets - Preliminary Element Interface Descriptions
	Architecture Design	- Functional Element Architecture
Inputs - Formulation Authorization Document - Project Formulation Plan - Advanced Study Results - Preliminary Science Requirements - Draft Level One Requirements	Build	- Consider during requirements development
	Integration	- Consider I&T during requirements development
	Validation & Verification	- Define Verification Strategy
	Operations & Maintenance	- Consider O&M during requirements development

Exit Criteria
- SRR Approval - Verified L2 Requirements Flow Down from L1 - Approved Systems Engineering milestones through PDR - Established Configuration Management Infrastructure & Procedure
Outputs
- Mission Operations Concept Doc - Mission (L2) Req's Doc - Functional Element Architecture Diagrams - Preliminary Element Interface Descriptions - Trade Study Results - Risk Management Plan - SEMP - Life Cycle Cost Estimates - Verification Strategy

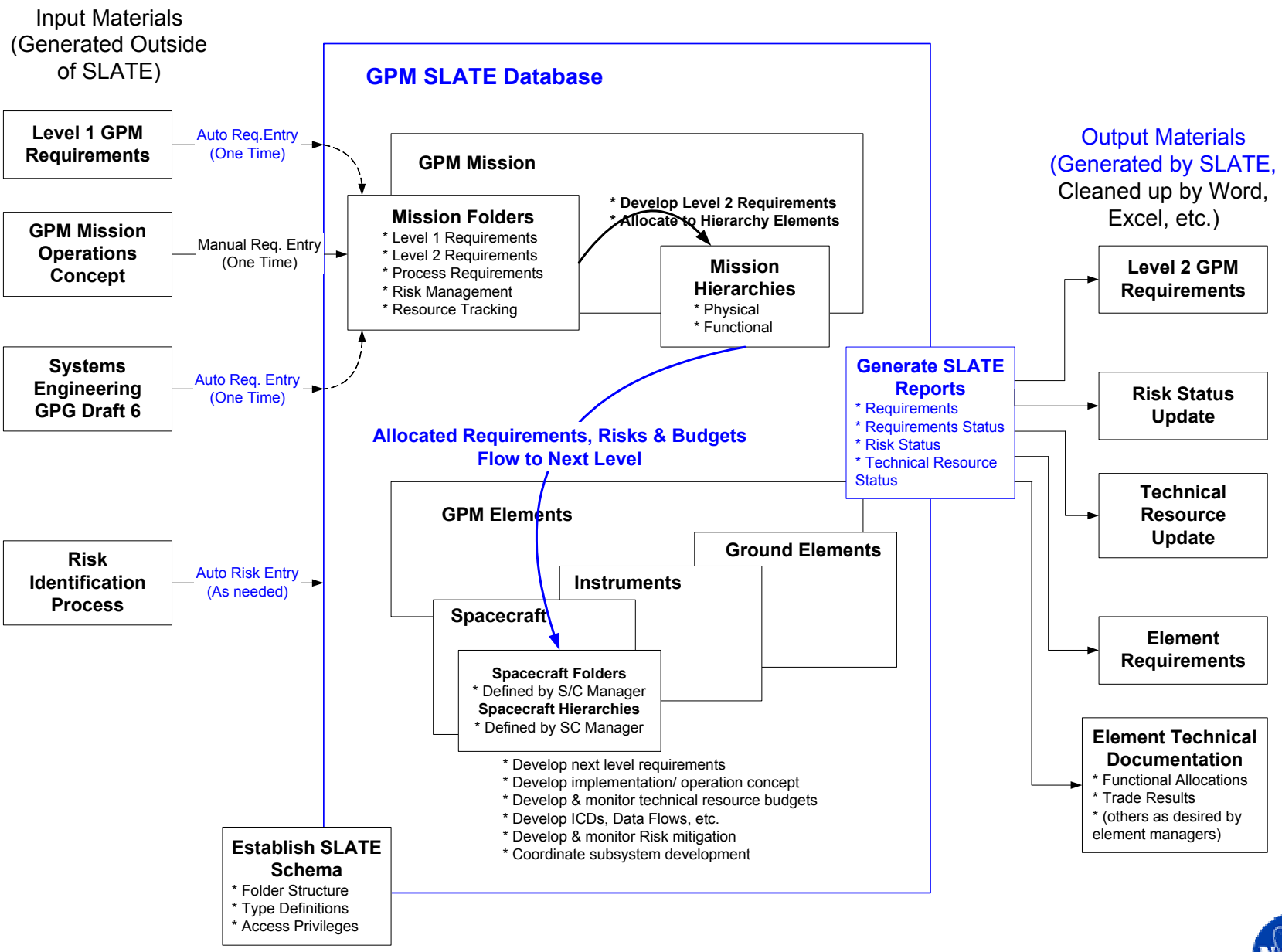
SEMP Process, Pre-SRR Team Responsibilities

	Mission SE	Ground Validation SE	Precipitation Data Processing SE	Mission Operations SE	Primary Spacecraft SE	Constellation Spacecraft SE	Instrument SE
Concept Development	Lead coordination and development Modify Ops Concept Document	• Provide Input	• Provide Input	• Provide substantial input	• Provide input	• Provide Input	• Provide Input
Requirements Development	Provide guidance Ensure communication Develop preliminary interface definitions Make mission level decisions	Develop L2 Ground Validation System Reqs. Define reqs. imposed on other elements Provide preliminary interface input	Develop L2 PDPS Reqs. Define reqs. imposed on other elements Provide preliminary interface input	Develop L2 Ground Operations Reqs. Define reqs. imposed on other elements Provide preliminary interface input	Develop L2 Primary S/C Reqs. Define reqs. imposed on other elements Determine Preliminary Resource Budgets Provide preliminary interface input	Develop L2 Constellation S/C Reqs. Define reqs. imposed on other elements Provide Preliminary Resource Budgets Provide preliminary interface input	Develop L2 Instrument Reqs. Define reqs. imposed on other elements Provide preliminary interface input
Architecture Design	• Perform functional architecture design for subsystems	• Provide architecture options	• Provide architecture options	• Provide architecture options	• Provide architecture options	• Provide architecture options	• Provide architecture options
Build	• Ensure team consideration	• Consider element build feasibility	• Consider element build feasibility	• Consider element build feasibility	• Consider element build feasibility	• Consider element build feasibility	• Consider element build feasibility
Integration	• Ensure team consideration	• Consider element testability	• Consider element testability	• Consider element testability	• Consider element testability	• Consider element testability	• Consider element testability
Validation & Verification	• Develop Verification Strategy	• Provide input	• Provide input	• Provide input	• Provide input	• Provide input	• Provide input
Operations & Maintenance	• Ensure team consideration	• Consider O&M	• Consider O&M	Consider O&M Provide O&M input to Ops Concept	• Consider O&M	• Consider O&M	• Consider O&M

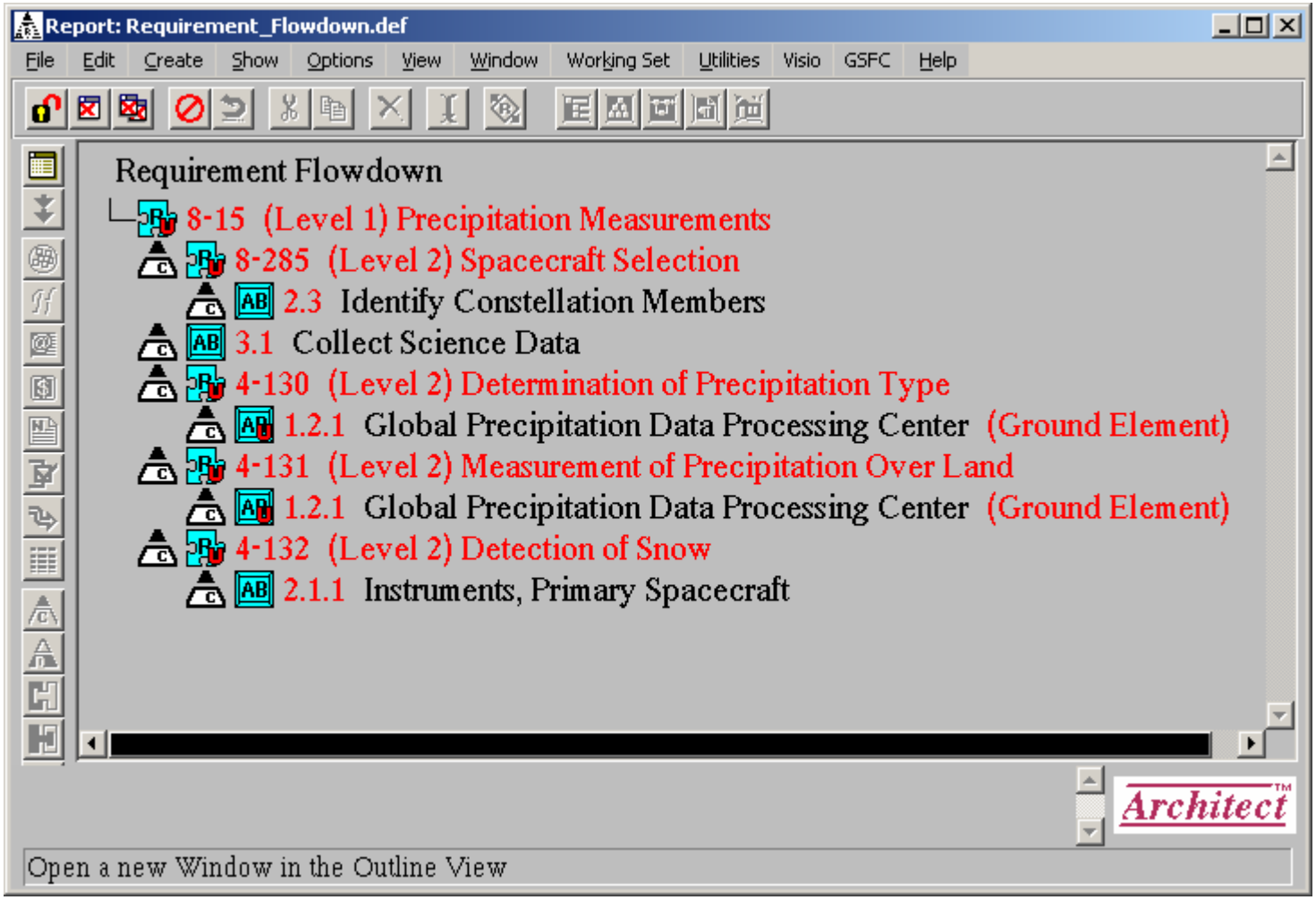
System Engineering Tool: SLATE

- ***System Level Automation Tool for Engineers (SLATE) by EDS***
  - *Originally developed by Texas Instruments (TI) in early 1990s for radar systems.*
  - *Spun off into its own company, which was bought by Structural Dynamics Research Corporation (SDRC) and recently by EDS.*
  - *EDS continues strong support for the software – sales and enhancements.*
  - *Locally, Northrop Grumman uses SLATE extensively.*
- ***More than simply a requirements management tool***
  - *Architecture based*
  - *Budgets (technical and programmatic)*
  - *Risk management*
- ***Interfaces to standard tools***
  - *Excel*
  - *Word*
  - *Visio*
  - *Project*
- ***GPM is pilot for GSFC using this type of tool***

Implementation in SLATE

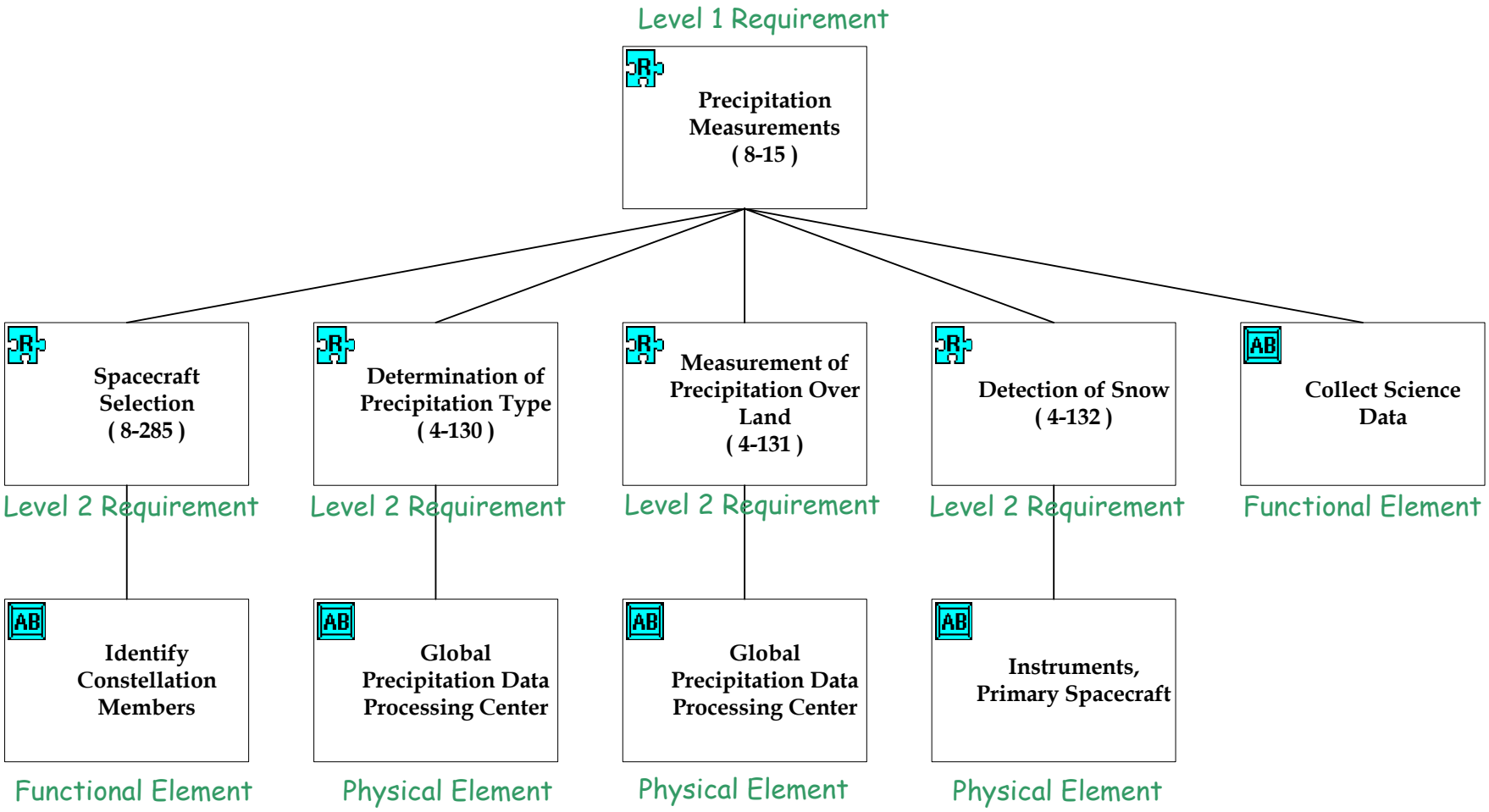


Flow-Down Example: Precipitation Meas Req



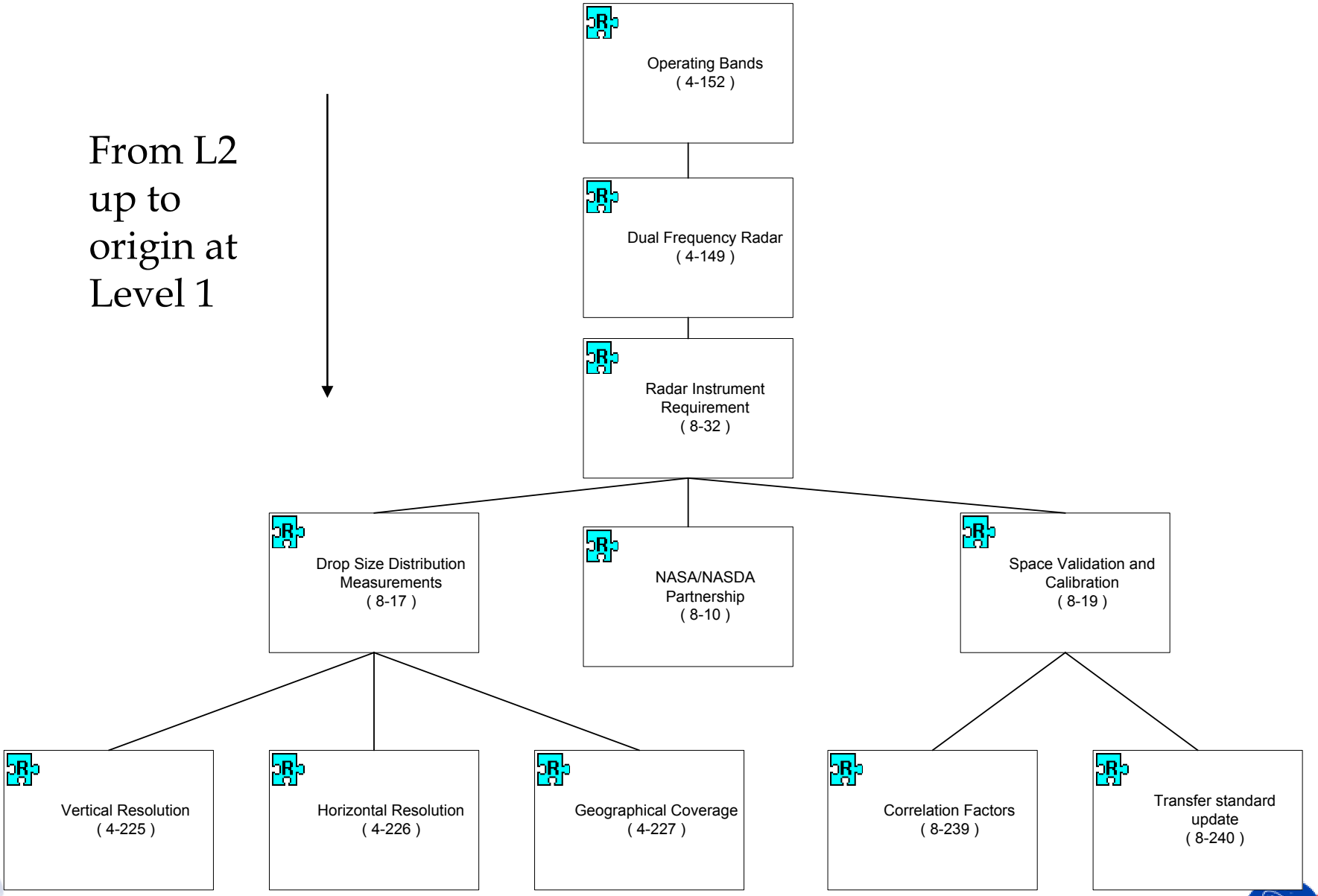
Flow-Down Example: Precipitation Meas Req

Tree View of Requirement Traceability as rendered by VISIO from SLATE



Trace-up Example: Operating Bands

From L2 up to origin at Level 1



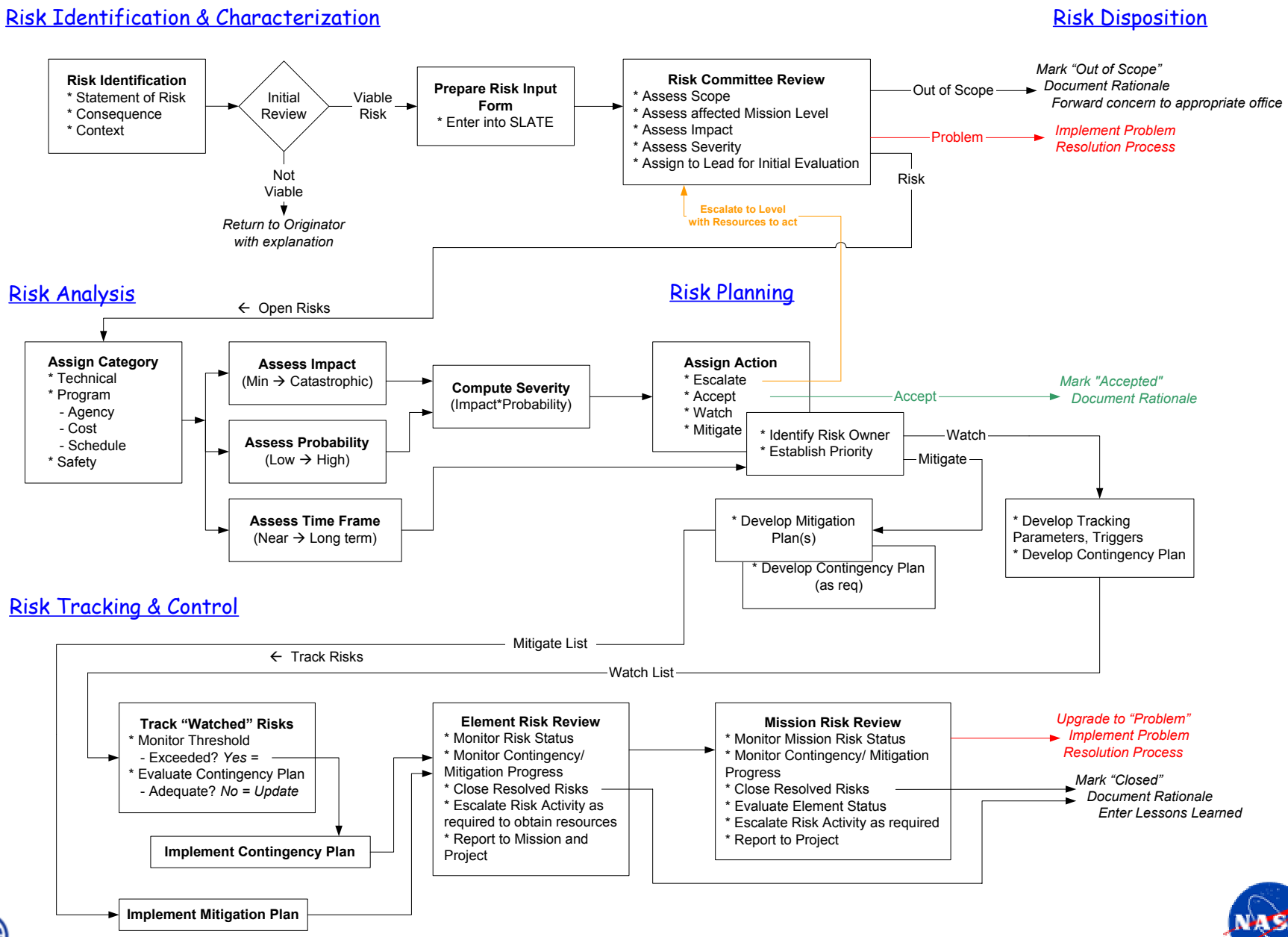
Risk Management

- ***Definition of Risk: An event that may occur and that has a negative impact on the GPM project if it does occur.***

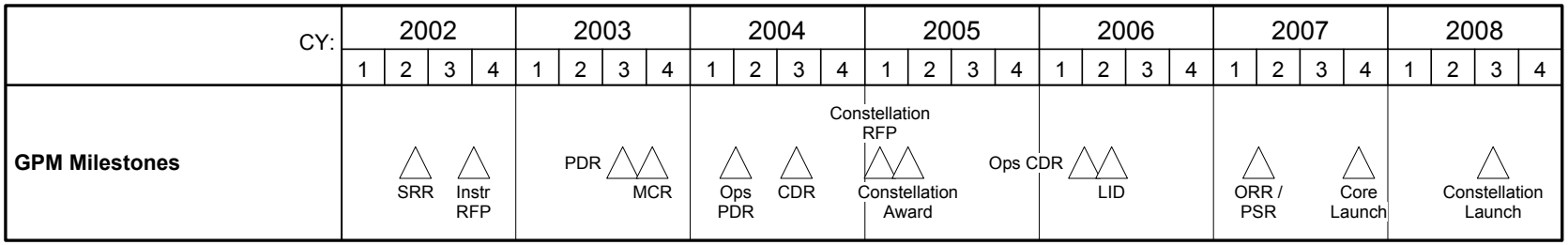
- ***A risk has three components:***
  - *Probability of occurring*
  - *Severity of impact*
  - *Timeframe*

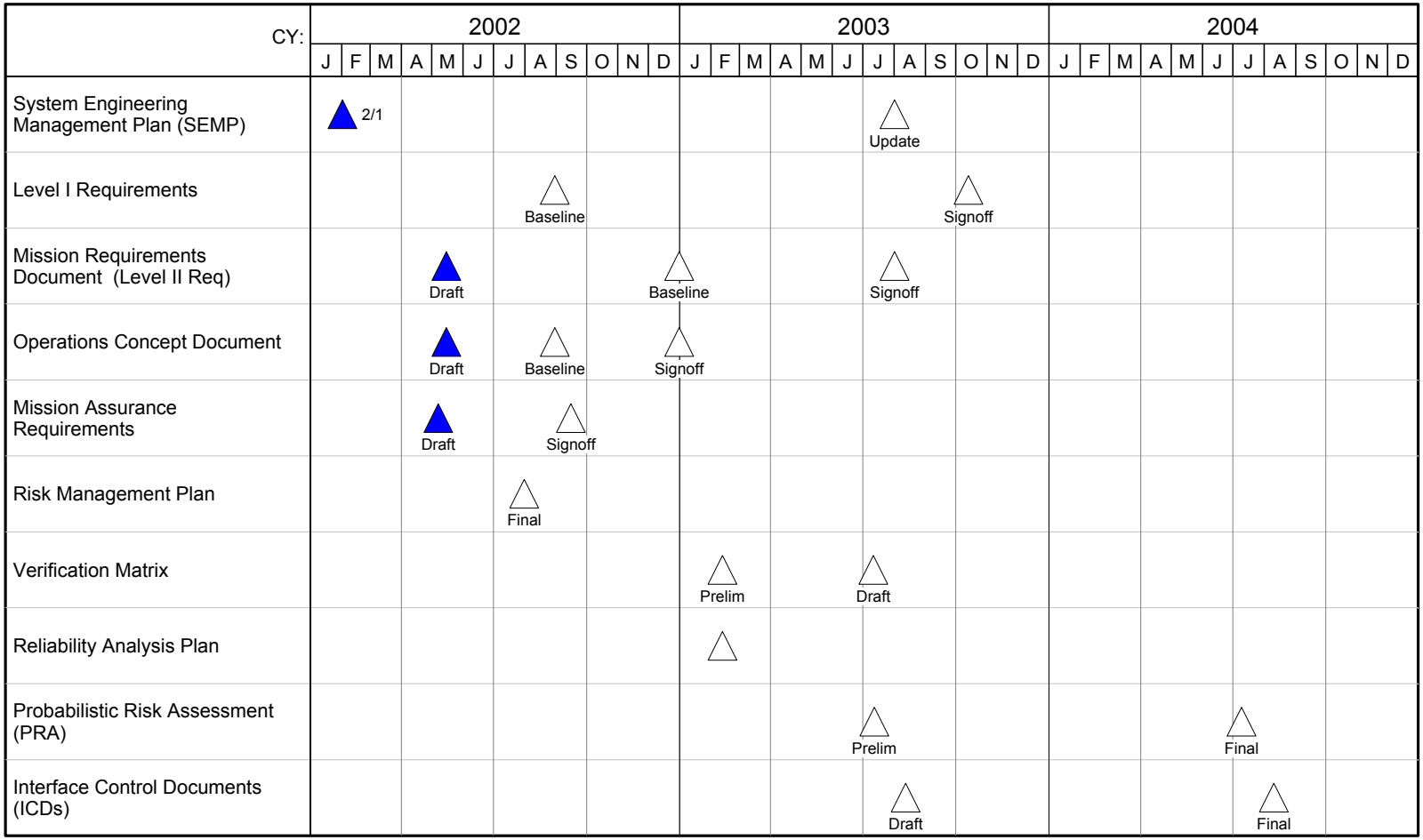
- ***Features of Risk Management:***
  - *Identification & Characterization*
  - *Analysis & Planning*
  - *Tracking & Control*
  - *Final Disposition*

Risk Management Process



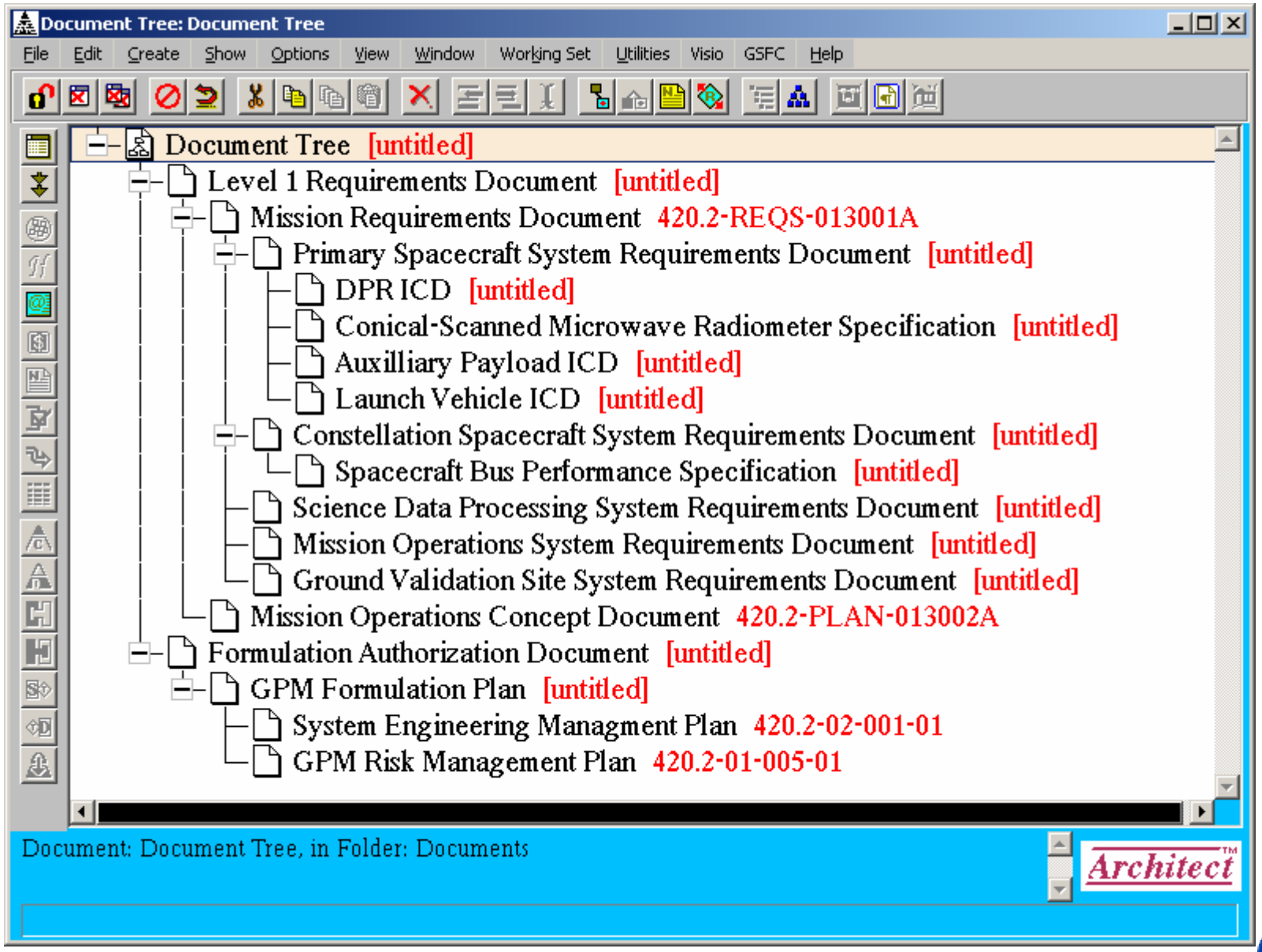
System Engineering Schedule





GLOBAL PRECIPITATION MEASUREMENT

Document Tree



Systems Engineering Status

- ***Requirements:***
  - *Level 1 Requirements Document Ready for Acceptance*
  - *Level 1 Requirements Entered into SLATE and Allocated to Mission Elements*
  - *Level 2 Requirements identified and allocated within SLATE*
  - *Draft Level 2 Requirements Document available for review*
- ***Risks:***
  - *Initial risk assessment at mission level complete and entered into SLATE*
- ***SEMP:***
  - *SEMP is signed off and being implemented.*
- ***Mission Design:***
  - *Architecture and Mission Concept well in hand and will be presented today, with draft operations concept document available for review.*

Wrap-up

- ***Exit Criteria***
  - *SRR Approval – In work*
  - *Verified L2 Req flow down from L1 – Done via SLATE*
  - *Approved Systems Engineering milestones through PDR – Done*
  - *Established CM infrastructure and procedure – In work*
- ***Outputs***
  - *Mission Operations Concept Document – Draft available, baseline Aug 2002, sign Dec 2002*
  - *Mission (L2) Requirements Document – Draft available, baseline Dec 2002, sign before PDR*
  - *Functional Element Architecture Diagrams – SRR presentation*
  - *Preliminary Element Interface Descriptions – SRR presentation*
  - *Trade Study Results – SRR presentation*
  - *Risk Management Plan – Draft available, sign Aug 2002*
  - *SEMP – signed-off, update before SRR*
  - *Life Cycle Cost Estimates – presented at TIM*
  - *Verification Strategy – SRR presentation*