



Project Management Fundamentals

Using NASA project management concepts for physics
instrumentation projects

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Physics 524



Introduction

- My experience at NASA/NOAA is supporting building, testing, and operating (mostly-) Earth observation satellites for weather and climate applications — involved applying project management principles

Some background on project management at NASA

- Critical at NASA (e.g., Apollo, Shuttle, Mars rovers).
 - Ex. Apollo: Complicated system with new technologies, tight timeline (1961 mandate, by 1970 landing on the moon)
 - Milestones, critical path concepts, phased reviews
 - Coordination among huge teams (100,000's of people)
 - Risk management (redundancy, simulations, contingency planning) - way more risk accepted for human space flight than nowadays
 - Lessons Learned (Apollo 1 fire)
 - Ex. GOES-R: Geostationary satellite with multiple instruments: Imager, lightning mapper, space weather instruments
 - Many different instruments on the same platform
 - Had to be an operational instrument — requirements for reliability dominated (leads to using mature technologies)
- **The practices (systems thinking, risk management, stage gates) spread across aerospace, defense, construction, IT, healthcare, and beyond, forming much of what we now consider modern project management.**

Project life cycle

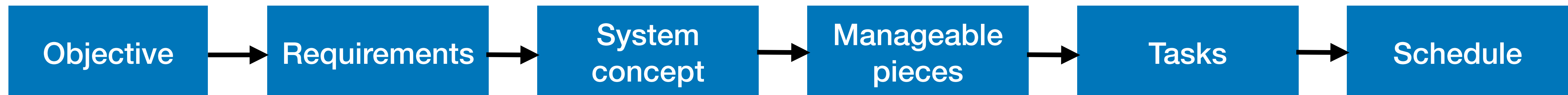
- What is a project? a temporary endeavor with a defined goal and deliverables.
 - Need to balance between scope, time, cost, and quality (the “iron triangle”)
 - Has phases to define its life cycle: NASA missions (proposal → design → build → launch → mission ops → post-mission).

Phases:

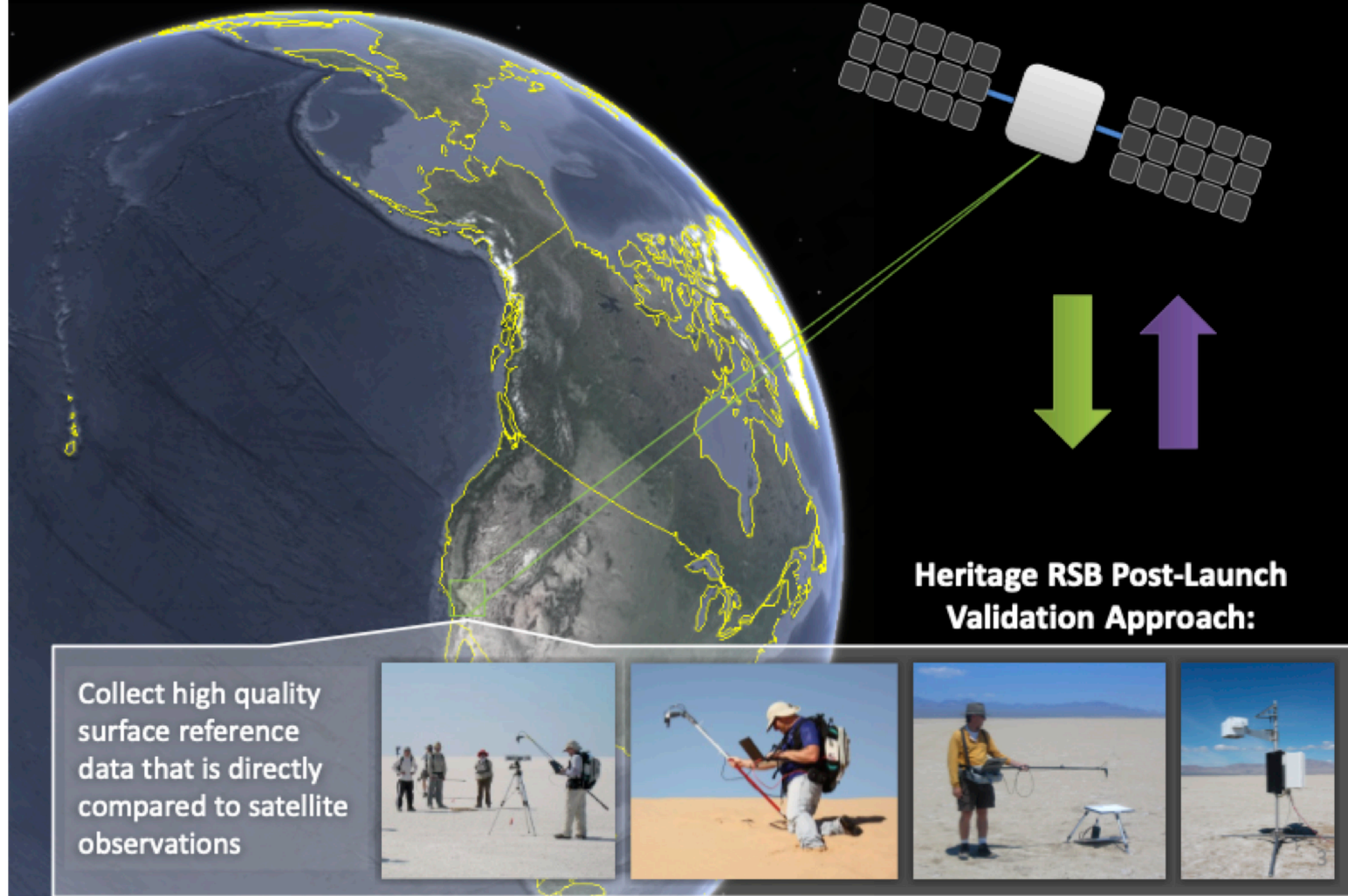
- **Initiation** – defining the mission/need, stakeholder buy-in.
- **Planning** – developing objectives, schedule, resources, risk analysis.
- **Execution** – carrying out the plan, managing teams.
- **Monitoring & Controlling** – tracking progress, adjusting.
- **Closing** – lessons learned, documentation, handover.

From objectives to a project plan

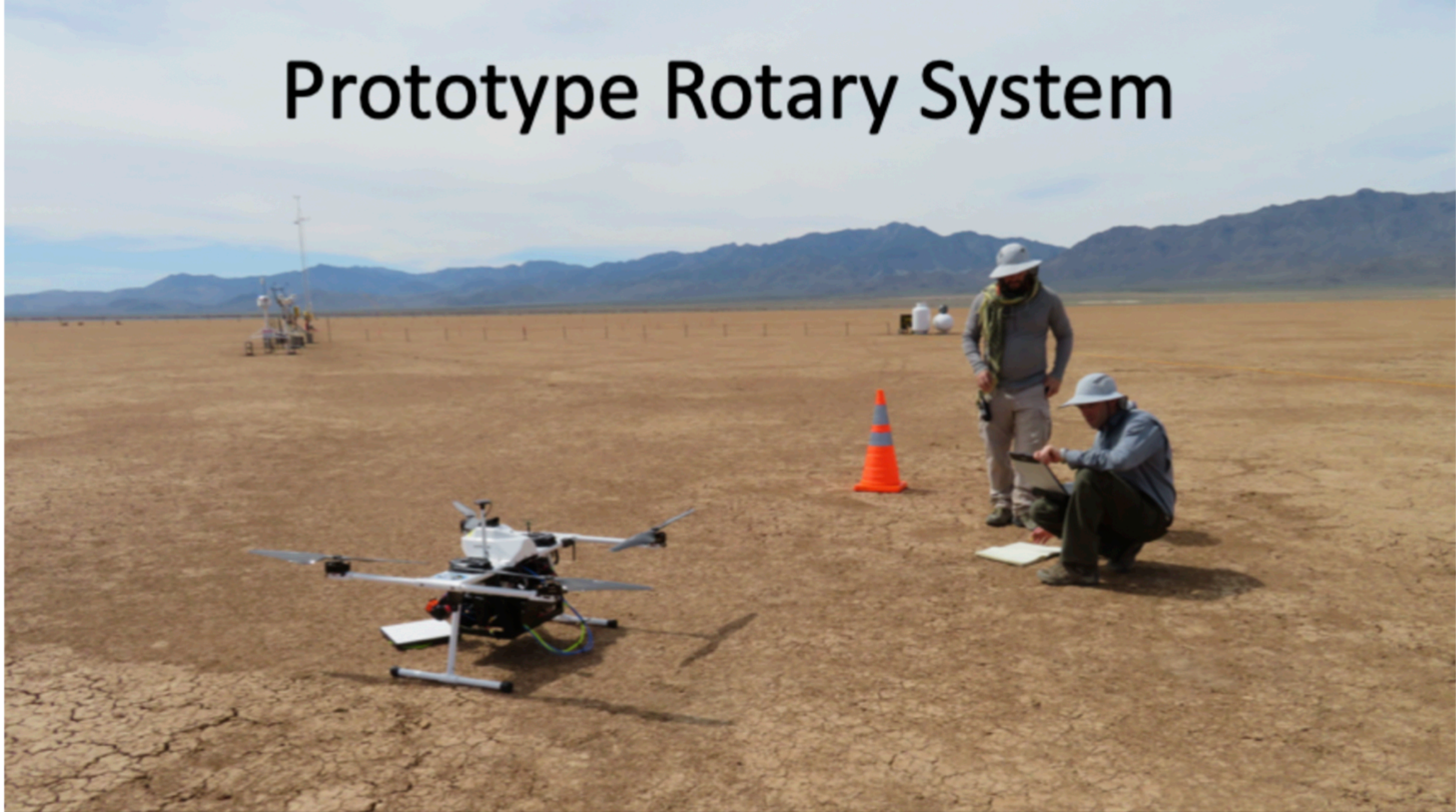
1. Define the project objectives
 - Building a system for what purpose
 - What level of maturity is needed to meet your goals?
2. Translate the objective into measurable requirements
 - Should be informed by science objective: what measurements are you trying to make?
 - Requirements examples: System has to get to a temperature of X for a detector to operate, system has to detect muons with X sensitivity,
3. Identify the functions needed to meet the requirements
4. Define the major elements of the proposed system
5. Decompose the elements into manageable pieces
6. Identify the tasks needed to complete each piece
7. Sequence the tasks to create a schedule



High to Moderate Resolution Satellite Sensors Leverage Small Uniform Earth Targets for Post-Launch Validation



Prototype Rotary System



NOAA Scientist Conducting UAS Sensor Calibration Prior to Flight along side a NOAA Mobile SURFARD Station

GOES-R near surface UAS feasibility demonstration study concluded with an operational environmental test in Red Lake, AZ (April 3-7, 2017)

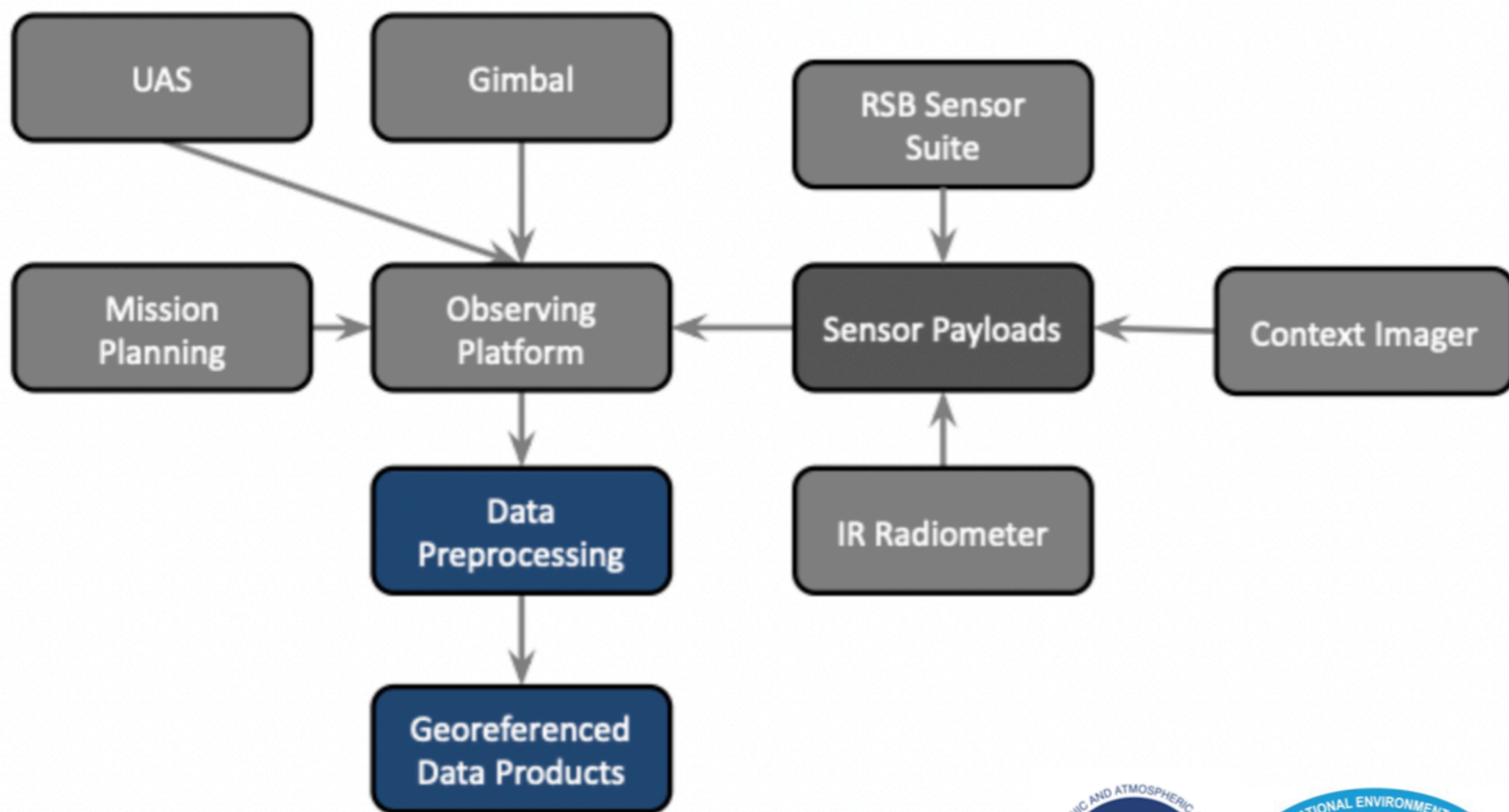
From objectives to a project plan

Step	UAS example	Question answered
Scientific objective	Validate the satellite sensor's radiometric performance using near-surface UAS measurements.	<i>Why are we doing this?</i>
Measurable requirements	Radiometric uncertainty <5% (k = 1).	<i>What must be achieved?</i>
Required functions	Measure radiance; point and stabilize the sensor; geolocate and time-stamp observations; record, process, and compare data.	<i>What must the system do?</i>
System concept	UAS, gimbal, sensor suite, command and data handling, mission planning, and data processing.	<i>What major elements are needed?</i>
Manageable pieces	Break each element down: sensor hardware, software, mounting, data products, integration, and testing.	<i>What must be completed?</i>
Tasks	Select, procure, design, calibrate, integrate, process, and flight-test.	<i>What work must be done?</i>
Schedule	Sequence tasks; add dependencies, durations, and milestones.	<i>When and in what order?</i>

From requirements to system elements

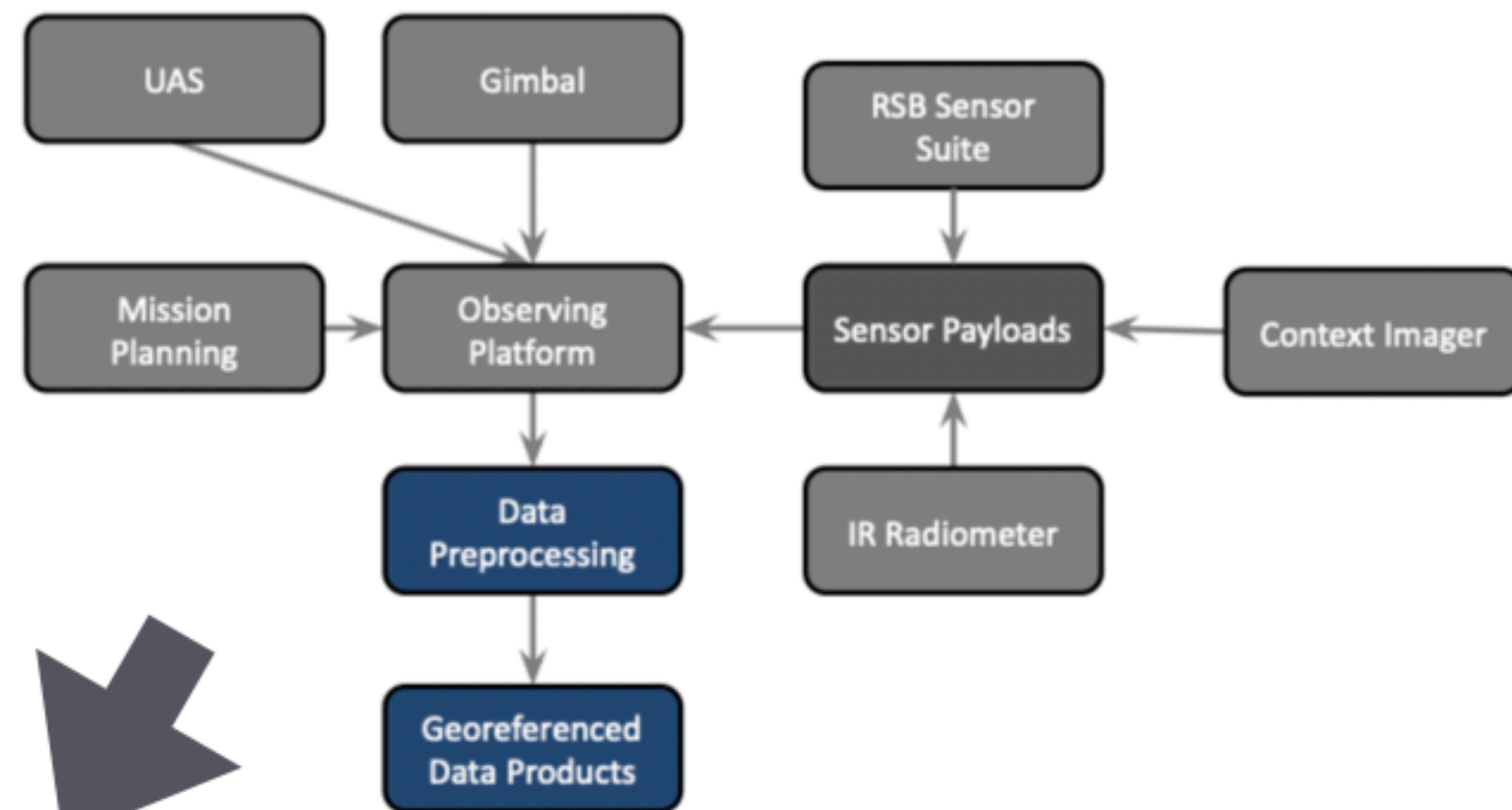
- Goal: To validate a satellite sensor's radiometric performance by making near-surface measurements with a UAS-based sensors system
- Requirement: <5% radiometric uncertainty ($k = 1$)

- Product Breakdown Structure - shows the physical/functional components of the system



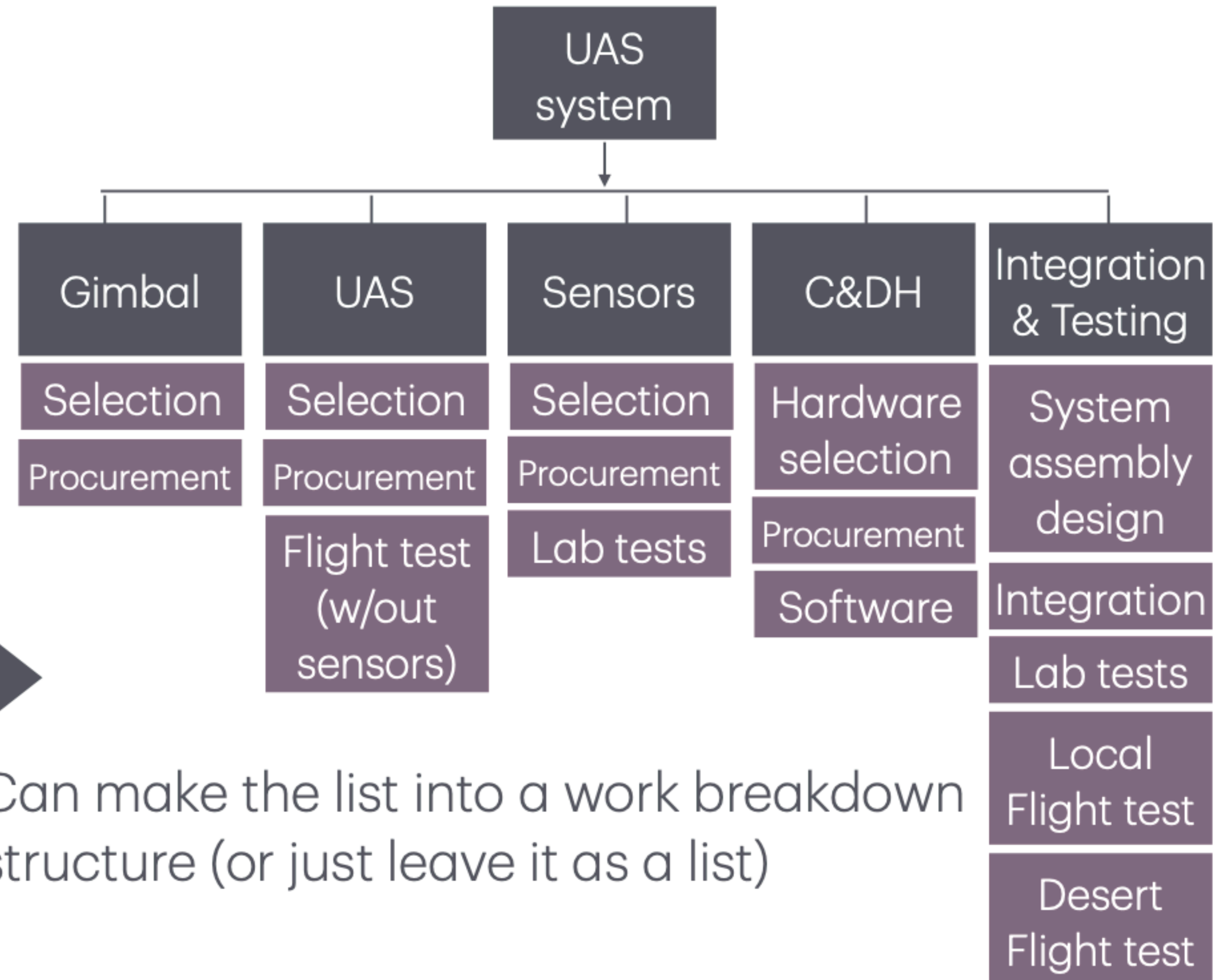
From system elements to project tasks

Break down each system element into manageable pieces, then identify the tasks needed to design, build, integrate, and test



Tasks

- UAS selection
- Sensor selection
- Command and data handling (hardware and software)
 - Includes UAS flight control, gimbal pointing control, sensor parameter adjustment, triggering, sensor and UAS (ex. GPS) data recording,
- Assembly design (how to integrate hardware onto UAS platform)
- Procurement of UAS and sensors
- Test sensors individually
- Integrate the sensors together and test
- Test the UAS (with weights) to check expected flight time, maneuverability

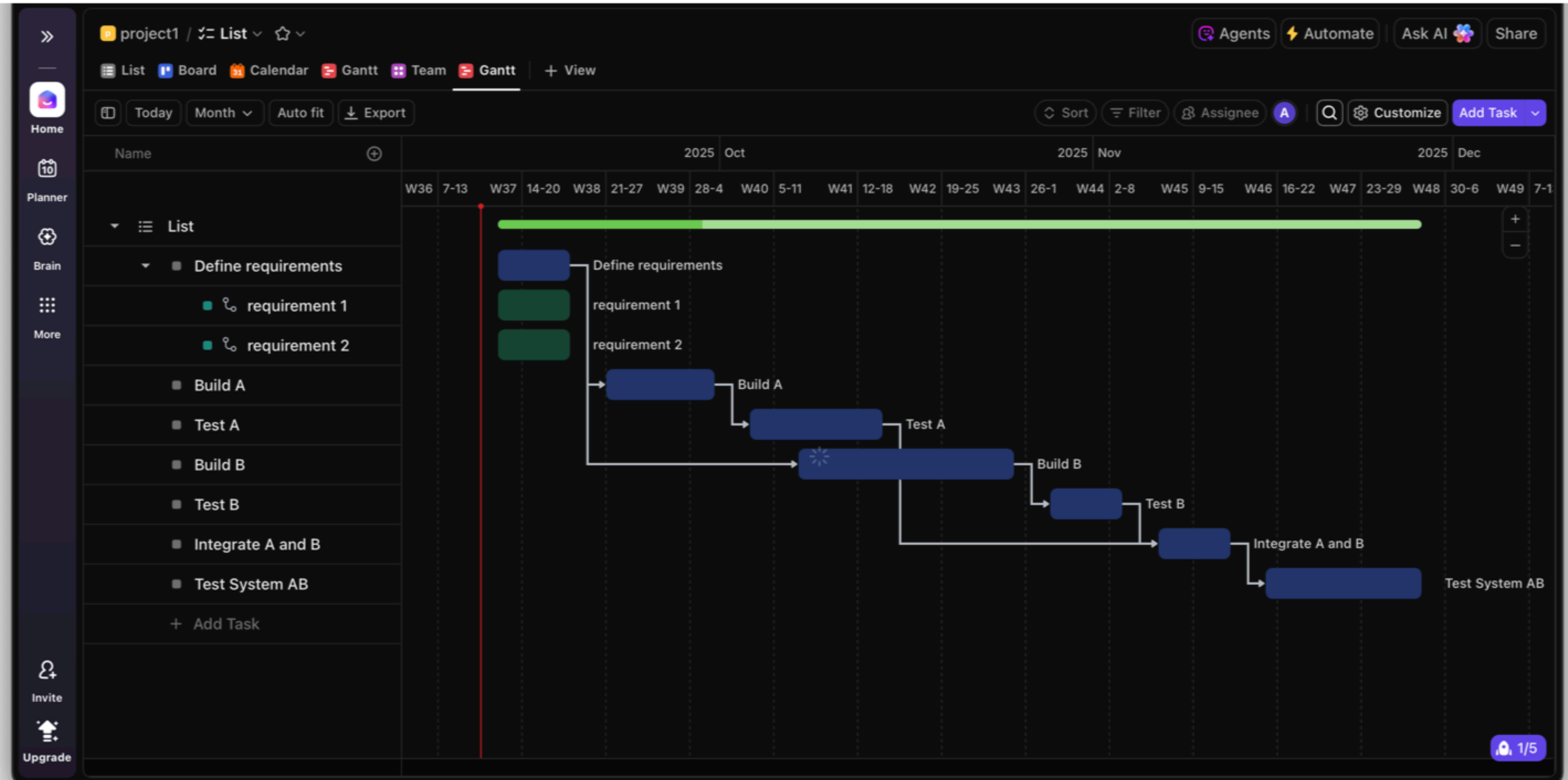


Can make the list into a work breakdown structure (or just leave it as a list)

Making a schedule

*Note that this software is not recommended (limited number of views for a free account)

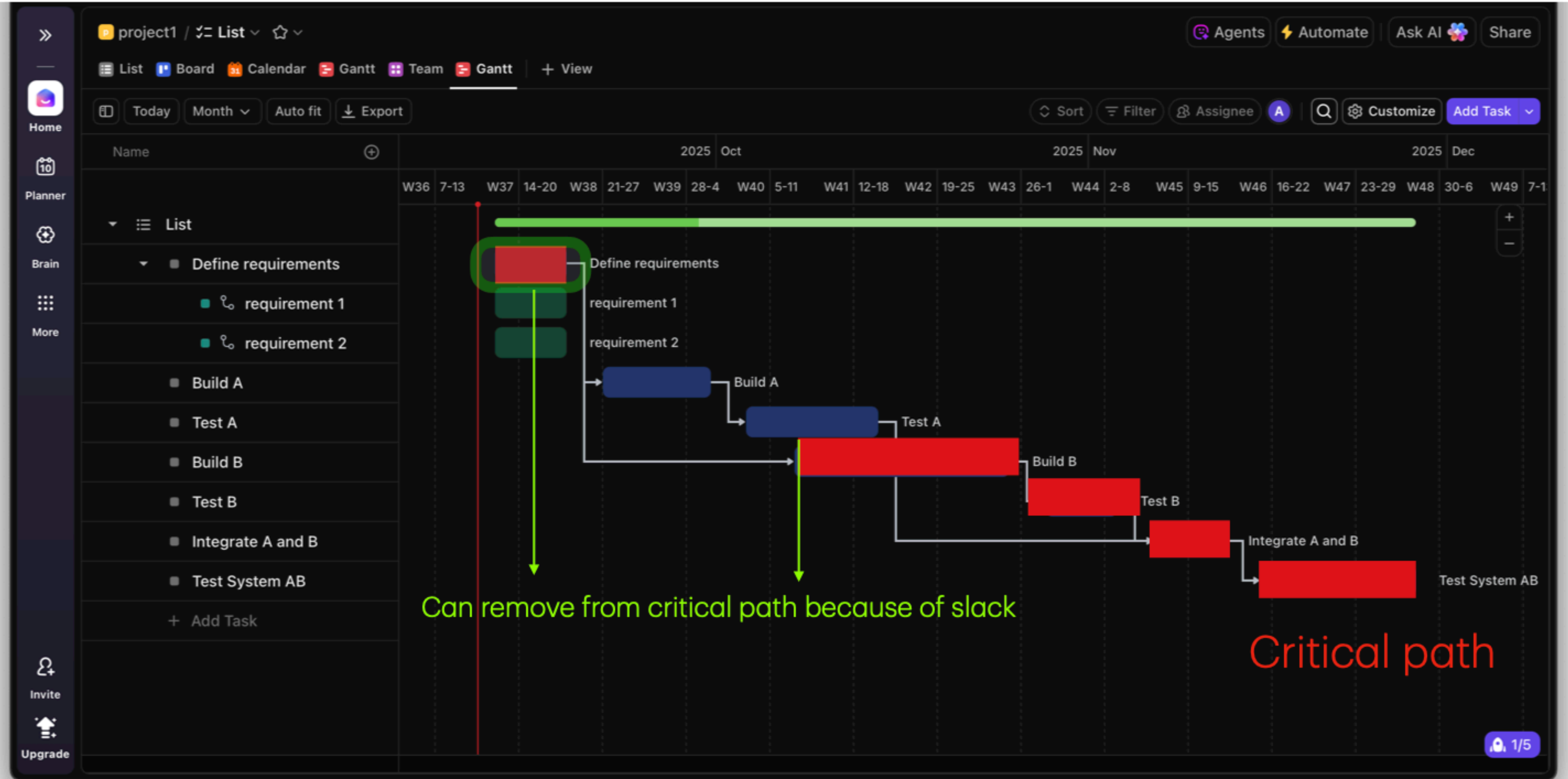
- Quick demo using software * (ClickUp) to form the schedule and identify the critical path
- Tasks
 - Define Requirements
 - Build A
 - Test A
 - Build B
 - Test B
 - Integrate A and B
 - Test System AB



Critical path: The longest sequence of dependent tasks in a project that determines the shortest possible completion time.

Making a schedule

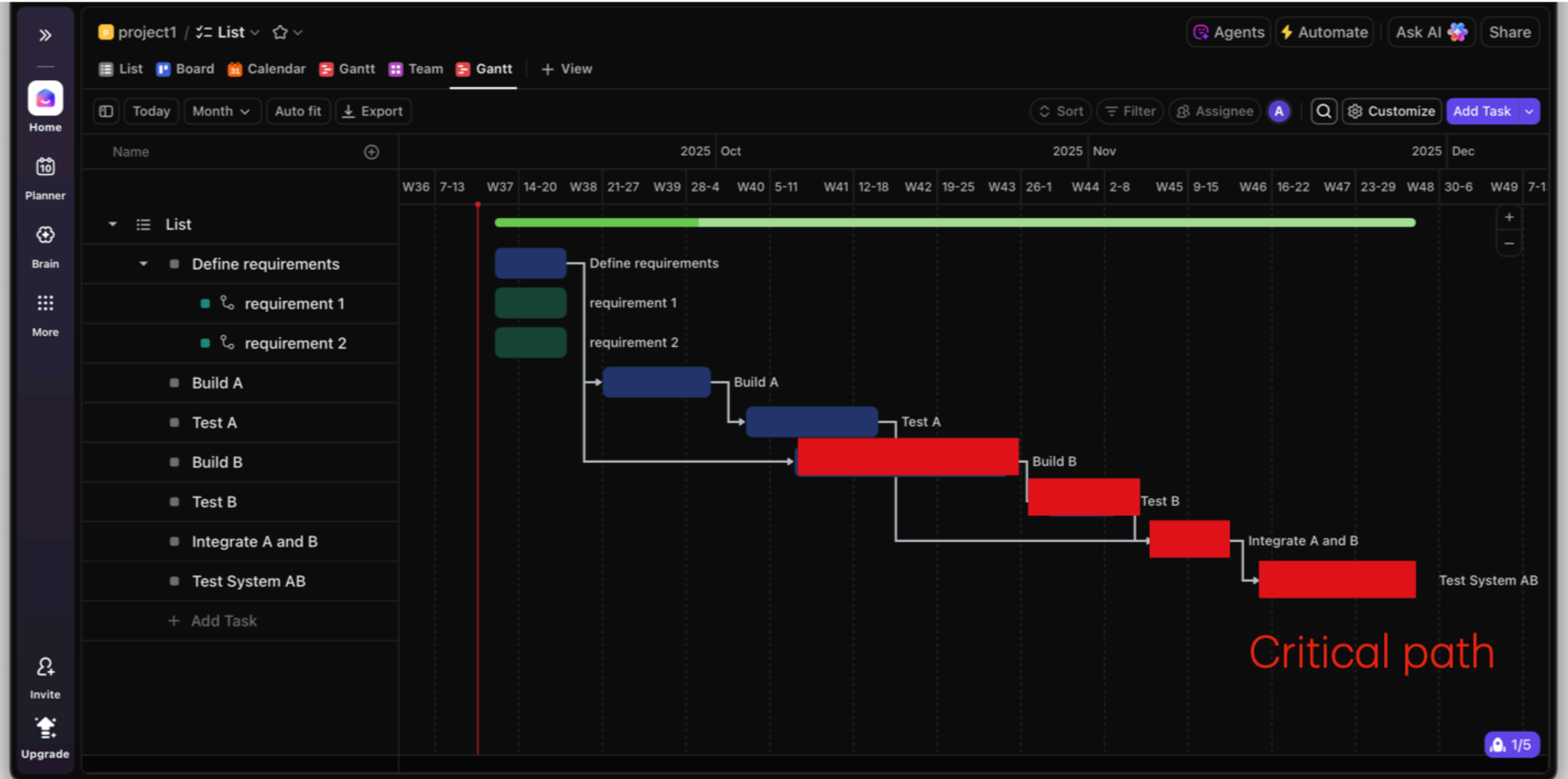
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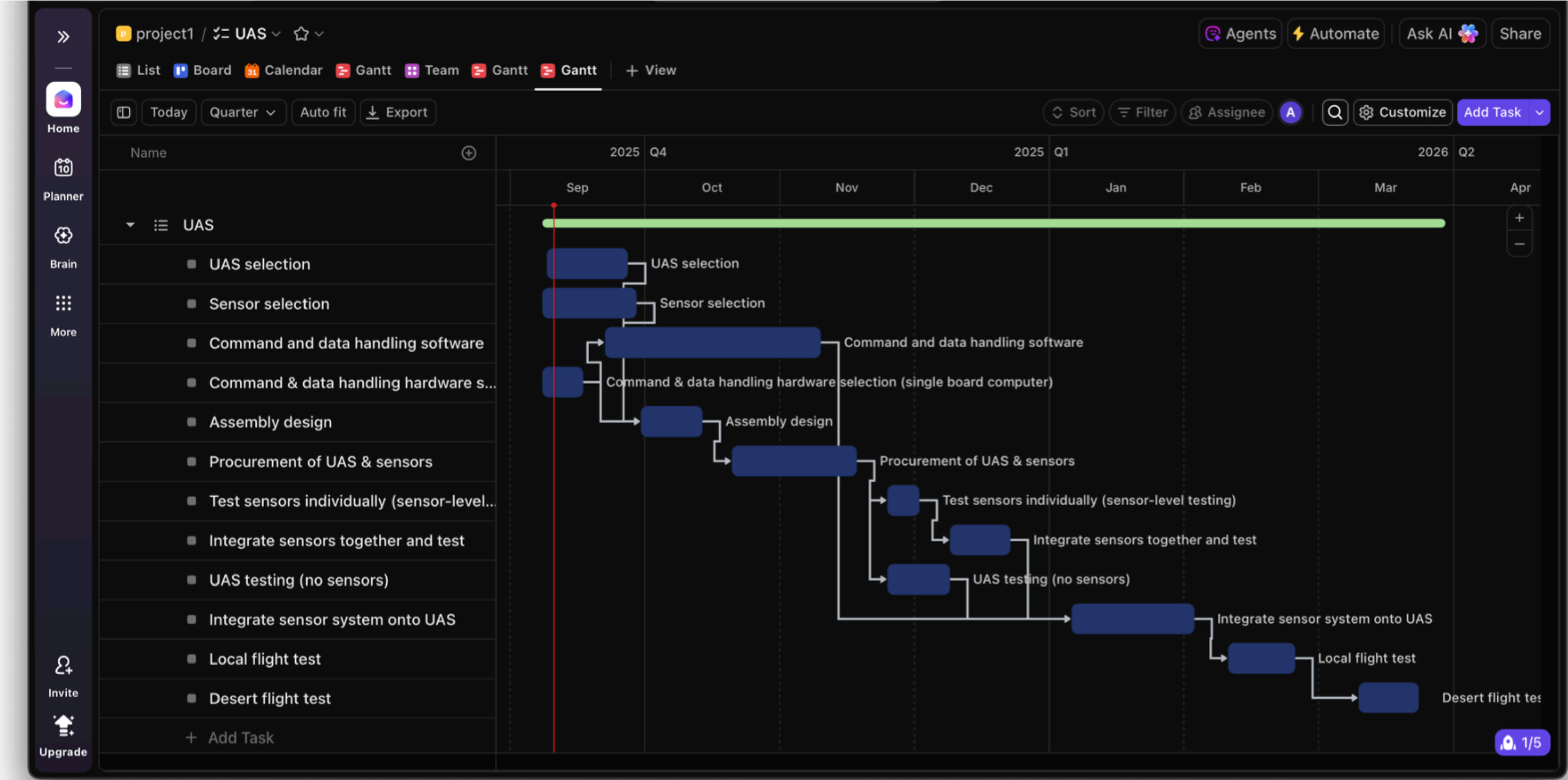
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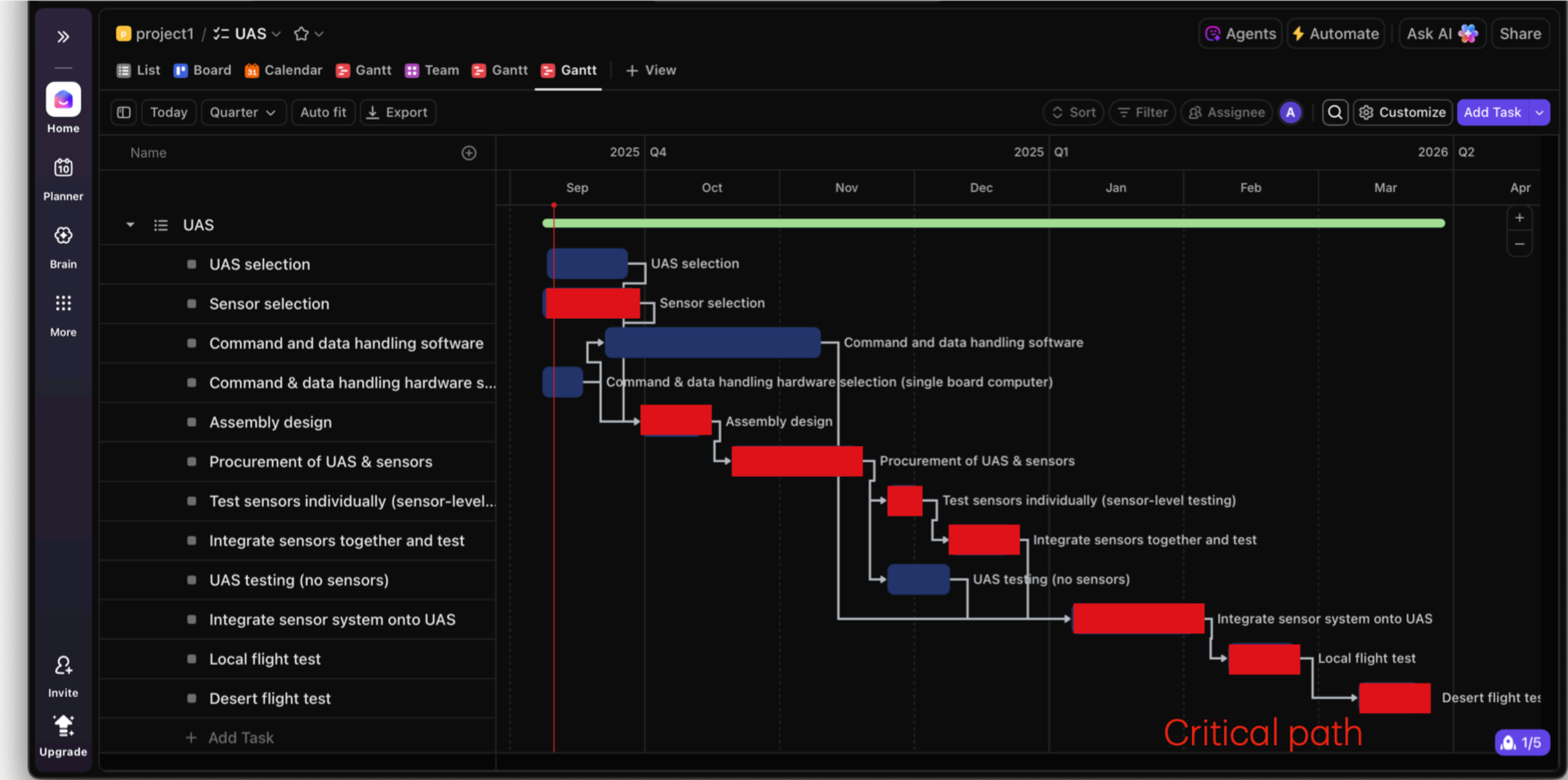


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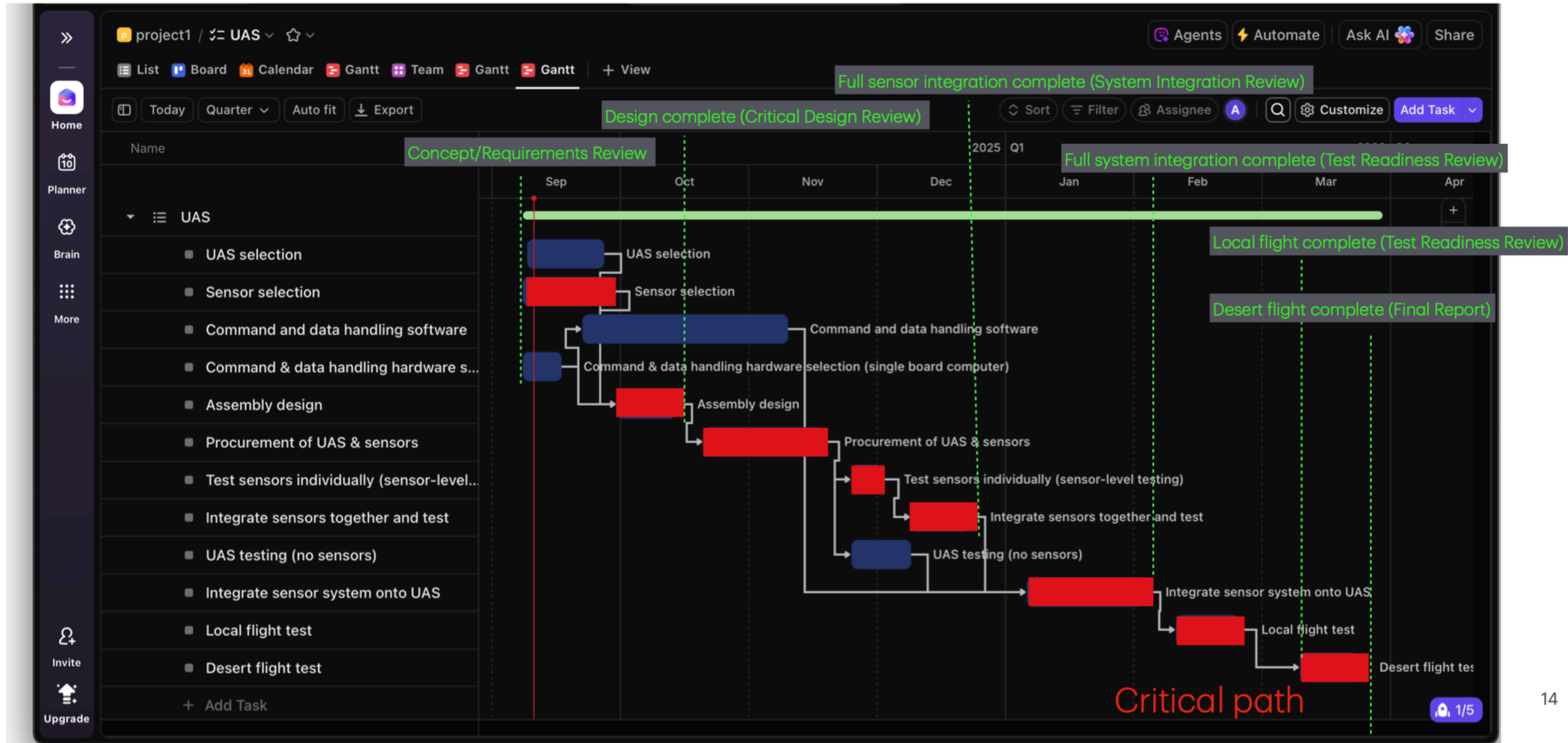
Back to UAS schedule



UAS schedule

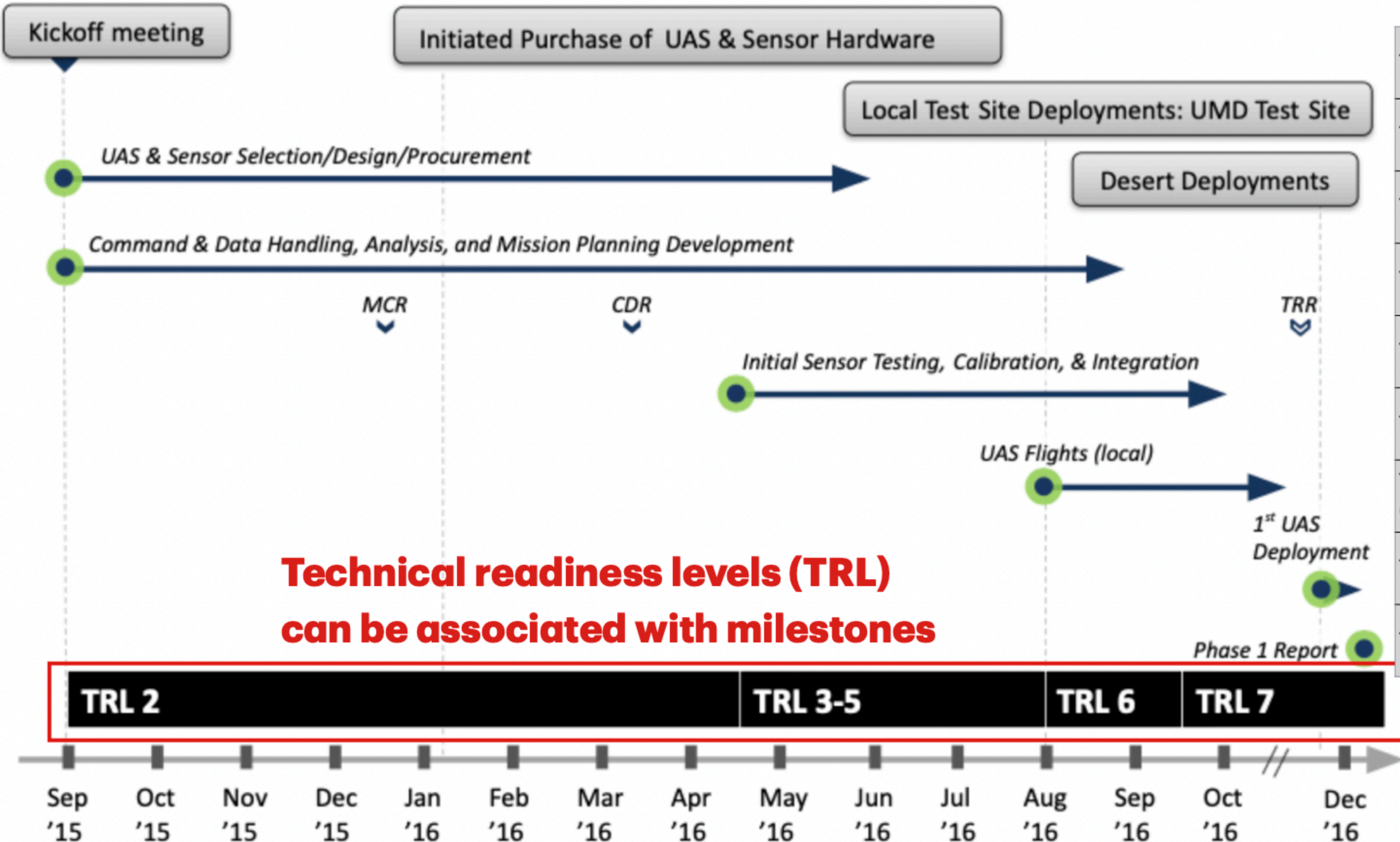


UAS schedule with milestones



GOES-R UAS Feasibility Demonstration Study Milestones & Schedule

Drafted & Submitted an initial set of near surface UAS science requirements to the NOAA Unmanned Aircraft Systems Program in January of 2015



TRL 1: Basic principles observed
TRL 2: Technology concept formulated
TRL 3: Experimental proof of concept
TRL 4: Lab validation
TRL 5: Validation in relevant environment
TRL 6: Prototype demonstration
TRL 7: System prototype in operational environment
TRL 8: System completed & qualified
TRL 9: Actual system proven in operation

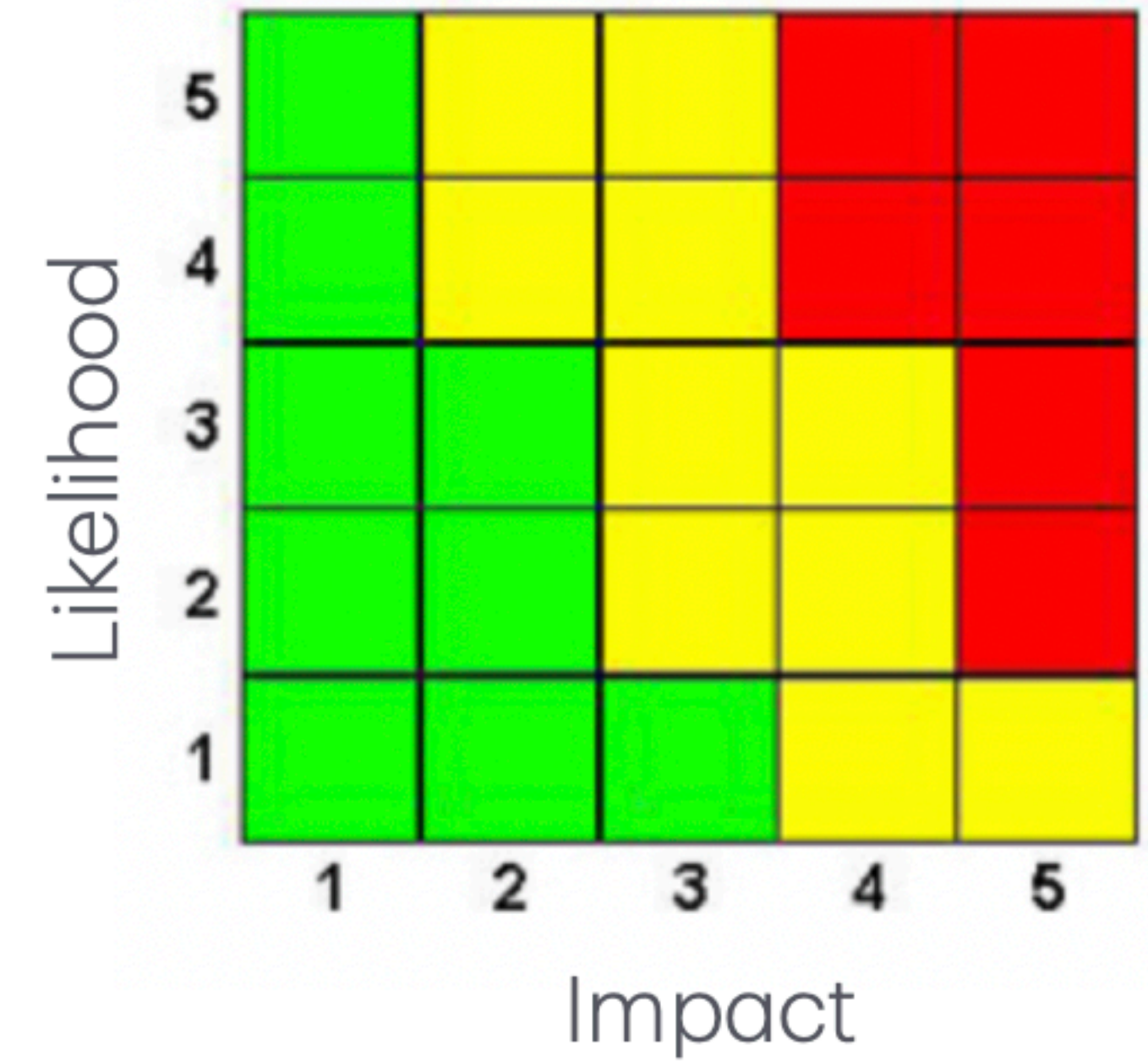


Risk management

- Risks: These are potential issues that could have a significant impact on the system performance, schedule, or safety

Basic steps for addressing:

- **Identify** - Review your system and look for potential issues that have a large impact on performance, schedule, safety
 - Example: Using a new sensing technology, where performance has not yet been verified
- **Classify**
 - Briefly describe
 - Assess likelihood (low, medium, high or 1-5)
 - Assess Impact (low, medium, high or 1-5)
- **Mitigate**
 - Describe mitigation steps: ex. Design redundancies, alternative parts, reallocation of resources



Risk description	Likelihood	Impact	Mitigation

Communication and leadership

- Establish clear communication channels - slack channel, weekly tag-ups
- Provide regular status updates, reviews, documentation including lessons learned
- Lead by enabling: Set the direction and allow group members to execute
- Build effective teams by listening to everyone's perspective

Wrap-up

- Project management provides a framework to effectively plan and execute a any project.
- Some key steps:
 - Formulate a clear objective (scope) for your project. Link the science objective with quantitative technical requirements
 - Propose a solution or system that can meet these requirements:
 - Breakdown all the physical and functional components
 - Link these components to tasks
 - Create a schedule, identify the critical path, and identify milestones; modify as project progresses
 - Identify, classify, and mitigate risks to performance, safety, or schedule
 - Communicate regularly, document progress, and lessons learned along the way

Homework

Create a preliminary schedule, identify the critical path (from tasks and dependencies), and identify milestones for your project

Recommended Project Management Tools:

- ProjectGantt - \$5
- Gantt san- free

Note: You may use other software if you wish (even Excel, Powerpoint), as long as you clearly list the tasks, mark the dependencies, critical path, and milestones

Due September 24, 2026