Problem Definition: Phase-End Summary

Team Vision for Problem Definition Phase

What did your team accomplish during this phase?

What we accomplished:

- Identified basic purposes and use-cases for the timecard and it's future possibilities.
- Preemptively researched existing time cards. (Meta, Safran, etc.)
- Obtain basic information in order to brainstorm possible restrictions and requirements.
- Identified basic engineering requirements and standards.
- Recognized risks due to spoofing and jamming.

Methods

Briefly describe how you went about defining the problem. For example, did you conduct interviews or focus groups? Did you use the existing hardware/system/process yourself? Did you observe others? Did you reverse engineer a competitor's product?

- The problem was initially defined by the description given by the customers of this project (Philip Linden and Ashley Kosak)
- Specifications were benchmarked against two competitor products
- Videos and documents provided by the customers were viewed
- Additional research was performed on relevant terms and applications
- Specific details were discussed with the customers in a video call meeting

Problem Statement

Your Team's problem statement goes here as defined by your customer. Describe the current state and the desired future state with deliverables.

The current ready-to-use space-qualified precision timekeeping devices available cost hundreds to millions of dollars.

The goal of this project is to design and build a derivative Time Card that meets the form-factor and environmental constraints of a CubeSat that is a low-cost alternative. It must have comparable performance under $10k.

The functional prototype must meet drift requirements with statistically significant confidence and it must be an open source design. Additionally, the size, weight, and power characteristics must be compatible with 12U cubesat or smaller and operational characteristics compliant with NASA LunaNet Standard. The timekeeping drift must be less than 30 nanoseconds per Earth day. The atomic clock must survive deep space conditions for at least 10 years and be widely interoperable with existing spacecraft systems.

Source: EduSource Information

Team Values & Interactions

Using your DISC homework, briefly describe your team's most important values, how you plan to address conflict within the team, how you will hold one another accountable, and how your team plans to communicate outside of class.

5 Values

- Timely communication
- Honest feedback
- Relatively equal contribution
- 100% effort on all tasks
- Open minded

Conflict strategy - list pros and cons of situation, discuss them, and come to a final solution

Hold people accountable by providing honest feedback about the lack of effort from that individual

We communicate via text and slack outside of class.

Use Cases

Identify the different scenarios in which your project will be used. This will help inform your requirements and set bounds on specifications.

Scenario: Competition across colleges to sync time and measure distance between satellites using an atomic clock.

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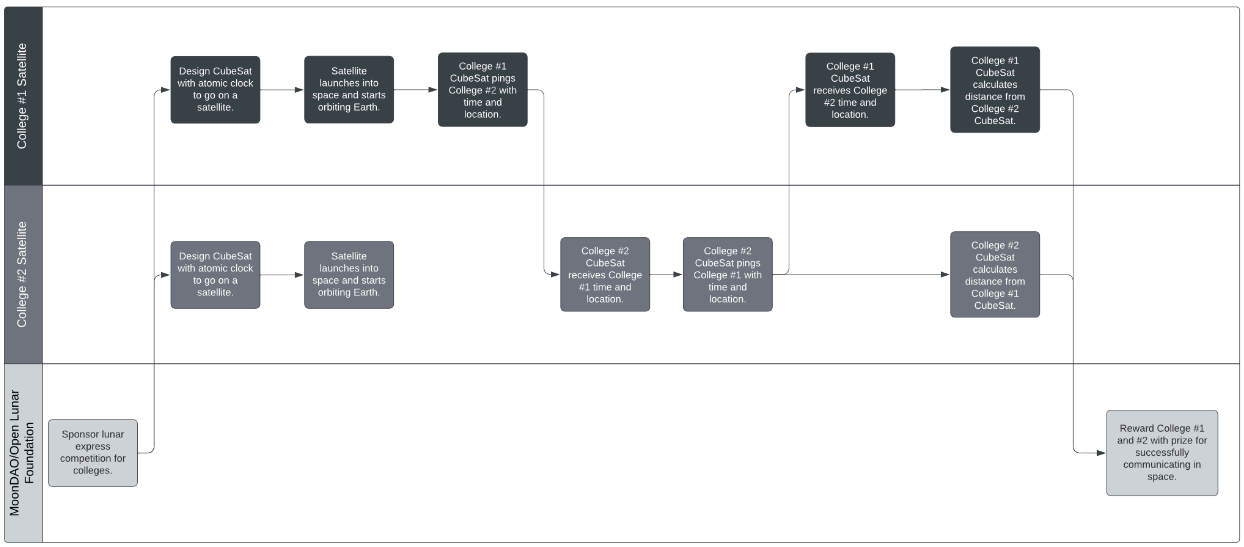
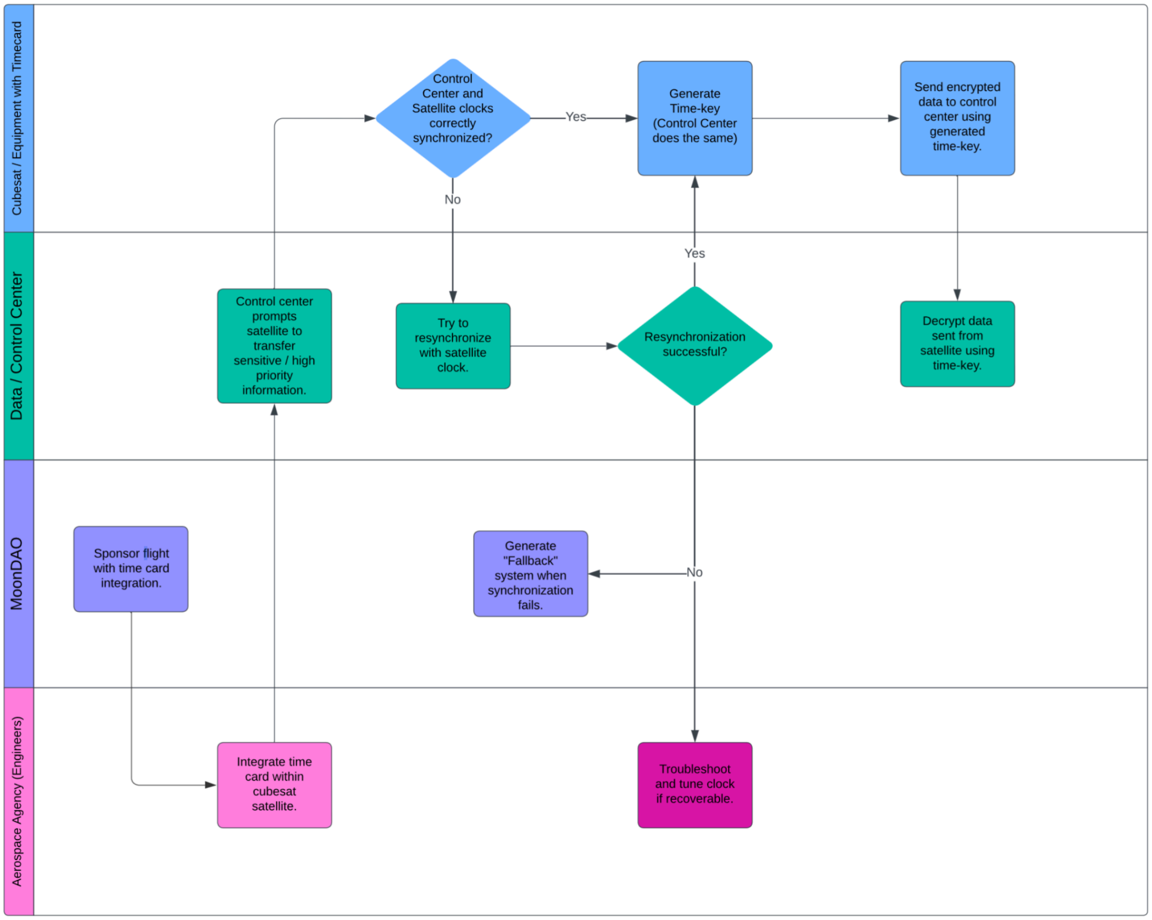


Scenario: Atomic clock/time cardused for time-based encryption between satellite and ground based communications.



Revised Aug 2024

Customer Requirements (Needs)

Team #:	22257	Team Name:	Space Time Card - CubeSat Atomic Clock
Date:	9/23/24 16:12	Document Owner:	MSD Timecard Team
Revision #:	1		

CR #	Importance	Description	Comments/Status
CR1	9	Design and build a functional derivative Time Card containing FPGA (and other processes) as well as other board components.	
CR2	9	Compatible with CubeSats and its standards	
CR3	3	Operational characteristics are compliant with NASA LunaNet Standard	
CR4	1	All components rated to survive deep space conditions (GEO and beyond) for at least 10 years	
CR5	1	Widely interoperable with existing spacecraft systems	
CR6	1	Minimize size, weight, and power characteristics	
CR7	3	Maintains accuracy over time	
CR8	3	Communicates with other time networks	

Engineering Requirements (Metrics & Specifications)

ER #	Importance	Source	Function	Engr. Requirement (metric)	Unit of Measure	Marginal Value	Ideal Value
S1	3	CR1	Funcional FPGA	Clock frequency	GHz	0.5	1
	3		Processing	Microcontroller/ Processor that supports RTOS with flash memory(512KB) and SRAM(128KB)	Binary Metric	Yes	Yes
S2	3	CR3, CR4	Survives in space according to standards	Operable within 0-70C	degrees C	0 - 70	-30 - 100
	3			Shall withstand vibe and shock testing IAW MIL-STD-1540	Binary Metric	Yes	Yes
	3			Shall withstand SMC-S-016 Figure 6.3.5-1 Minimum random vibration spectrum, unit acceptance test	Binary Metric	Yes	Yes
S3	9	CR2, CR5	Compatible with existing spacecraft systems	Has PCIe breakout board that connects to server	Binary Metric	Yes	Yes
S4	3	CR6	Size, Weight and Power Characteristics	Maximum 16cm X 8cm X 2cm(based on Safran timecard)	cm x cm x cm	16x8x2	16x8x2
	1			Maximum 5 kilograms	Kg	5	0.5
	1			Max average power	Watts	5	1
S5	3	CR7	Accurate over time	Timekeeping drift	Nanoseconds per Earth day	30	0
S6	9	CR8	Utilize GNSS communications	Synch on-board time to within minimal tolerance around UTC	Nanoseconds	60	30
	1		Server Communication	Synch other systems' times to within minimal tolerance around UTC	Nanoseconds	60	30

Goals

- Define engineering requirements (ER): measurable and testable parameters by which the success of the project can be determined

Instructions

1. Seek input from clients and other relevant stakeholders using interviews, observations, focus groups, etc.
2. Refer to standards, regulations, and benchmarks to supplement client input. The RIT library maintains an infoguide with standards references for students here: https://infoguides.rit.edu/standards
3. Perform basic (1^{st} order) analysis to establish the feasibility of the requirement targets

Required Artifacts

- A completed ER list in the Requirements and Testing.xlsx document (tab 2)
- A snapshot in time of this document: include the engineering requirements table as of your Problem Definition Review here.

Constraints

Factors, usually system-level, that **limit** your design space (e.g., cost, total weight, total footprint, total power available). Supplement your ER list with Constraints.

- Size, weight, and power characteristics are compatible with 12U CubeSat or smaller
- Timekeeping drift less than 30 nanoseconds per earth day
- Include an FPGA for custom programmable logic synthesis
- Integrated Atomic Clock for timekeeping
- Completely Open-Source
- Maximum budget constrained to $10k, preference placed on under $5k

House of Quality

- All engineering requirements are traceable to customer requirements.
- All customer requirements are addressed by either an engineering requirement or constraint.
    - This ensures that all constraints and engineering requirements are necessary.
- From the ER-CR mapping, it can be concluded that the team has captured the essential needs of the customer.

Open Items

Use this space to call out unresolved items and provide your plans for resolution. For example, if you have some ERs with TBD targets, how and when do you plan to finalize those targets?

- Deep space durability needs to be further understood with respect to the project and what it entails.
    - More research can be done to understand alternative devices and how this goal was achieved
    - This can be done during the start of Phase 2.
- If a SOC can be used instead of an FPGA and microcontroller
    - The advantages and disadvantages of each can be weighed to determine which is the better option.

Design Review Materials

Be sure to update the following in your Phase 1 folder:

- Pre-read including agenda items for customer and presenters
- Presentation and/or handouts
- Notes from review, including action Items
- Supporting documentation for your client.

Share this page and relevant supporting documents with your client in preparation for the review. This will ensure that they know what you will be presenting and how to view all your work. Draft work you've been keeping in a Google drive should be copied to this phase folder in EduSourced as a snapshot in time of your progress.

Goals for next phase

As a team, where do you want to be at your next review? Visualize for the customer what the end state for the next phase will be. What are your goals for the next phase?

Individual phase plans (what did I plan to do, what did I actually do, what did I learn, what do I plan to do next, and what blockers might I have) are due to myCourses.

Required Artifacts

- Include a list of planned tasks, by team member, for the upcoming phase.
- *A snapshot of your overall project plan (Gantt chart) should be linked to this document, and it must be included in your EduSourced Phase folder*

Goals for Next Phase:

- Identify Possible FPGAs, Microcontrollers, CSACs, OCXOs, TCXOs.
    - Possible removal for the need of CSAC?
- Understanding of GNSS receivers and interfacing with previously mentioned atomic clock (Hardware vs software solutions).
- Verify functionality and environmental testing of prototype parts.
- Explore other open source projects. Obtain as a team fundamental operation and basic layout of the card.
- Identify possible hardware and software improvements and implementations (cost, speed, environmental resistance).
- Formal list of planned tasks (per team member) and overall project plan will be updated upon completion.