Introduction (0:00 – 1:30)

Slide 1: Title Slide "Good morning. My name is **C. Dhiya**, a B.Tech student in Computer Science with a specialization in AIML.

Today, I am honored to present my project titled **'Cryogenic System Dynamics and Vehicle Interface Analysis for GSLV and LVM3 Vehicles.'** This work was completed under the expert guidance of **Mr. K. Murali**, Engineer-SF at the Liquid Solid Fuel Facility (LSSF), SDSC SHAR."

Slide 2: Introduction "Let's start with the context. The **Cryo Control System** is the heartbeat of the launch infrastructure during the final countdown. It manages the critical supply of Liquid Oxygen (LOX) and Liquid Hydrogen (LH2) to the launch vehicle.

Specifically, we are looking at the **Intelligent Control System (ICS)**. Validating its performance is non-negotiable for mission safety. My analysis focuses on three specific areas:

1. **Accumulator Charging Systems:** Monitoring pressure cycles.
2. **Valve Timing.**
3. **Cryo Arm Retraction:** Analyzing how the booms move and retract.

The Problem? Analyzing this telemetry data manually is time-consuming and prone to error. **The Solution:** I have developed a **Python-based Automation Suite** that streamlines this entire post-mission analysis. It takes high-frequency telemetry logs and converts them into actionable insights using libraries like Pandas and Matplotlib."

System & Data Overview (1:30 – 3:00)

Slide 3: Datasets "To ensure this tool is robust, I worked with datasets from ISRO's two major launch vehicles: the **Mark-II (GSLV)** and the **Mark-III (LVM3)**.

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Regardless of the vehicle, the datasets contain common telemetry parameters: LOX and LH2 pressure measurements, accumulator charging/discharging values, and critical event timings like the UCU separation . Dealing with these massive Excel logs is where the automation begins."

Slide 4: System Architecture Diagram "Here is the high-level architecture of the system. The flow is linear and user-friendly:

1. The **User** interacts with a **Tkinter GUI**.
2. They upload the **Excel Inputs**.
3. This feeds into the **Data Processing Engine**, which splits into three parallel streams: Pressure processing, Timing processing, and High-speed (25 millisecond) data processing.
4. Finally, the **Table and Graph Generators** compile everything into a **Final PDF Report**."

Slide 5: Input and Data Preprocessing Stage "The reliability of any analysis depends on the quality of the input. We use a **Tkinter GUI** for file uploads, allowing the user to select files and define the specific Event Date and Time.

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Under the hood, we use **Pandas** to load these files, supporting multiple Excel formats. But we don't just load data; we validate it.

- **File Validation:** We check if the file exists to prevent crashes.
- **Column Validation:** I implemented a normalization function using Regex. It removes special characters and converts headers to uppercase. This ensures that even if the raw log has slightly different column naming conventions, the system can still find the data it needs."

Core Logic & Analysis (3:00 – 7:00)

(This is the technical core of your presentation. Speak clearly here.)

Slide 6: Table 1 Logic (Accumulator Charging) "Now, let's look at how we generate the technical tables. **Table 1** focuses on **Accumulator Charging** at specific milestones. The logic here is based on a 'Snapshot' approach.

The system takes the Launch Time and calculates offsets, like T-20 minutes or T-10 minutes. It then performs a **Nearest Neighbor Search** in the dataframe to find the exact row that matches that target time. From that row, we extract the Header and Pivot pressures for both LOX and LH2. This gives us an instant health check of the system at those critical moments."

+2

Slide 7: Table 2 Logic (Charging Timings) "Moving to **Table 2**, we analyze the **Charging Cycles**. Unlike the snapshots in Table 1, this requires mapping sequential events. The system reads the lists of Charging Times and Discharging Times.

I defined a logic array of steps—for example, the cycle going from 0 to 230 bar, then discharging to 180 bar. The algorithm iterates through these steps. If the step implies 'Charging', it pulls the next value from the Charge list. If it implies 'Discharging', it pulls from the Discharge list.

+1

Crucially, the raw data is in PLC integers. I wrote a conversion function to translate these integers into a readable **HH:MM:SS:MS** format."

Slide 8: Table 3 Logic (Cryo Arm Data) "**Table 3** reports on the **Cryo Arm Retraction**, which is a high-speed event. Here, we are looking for specific flags, like 'UCU Separation' or 'Boom at 37 Degrees'.

The processing logic handles different data types differently:

- For **Pressures and Angles** (like the 37-degree mark), the raw values are often scaled up, so the system automatically divides them by 100 to get the actual float value.
- For **Timers** (like Source Cutoff), we again apply the PLC-to-Time conversion. This ensures the final report contains physically meaningful units, not raw database values."

Slide 9: Pressure Graphs "Data is best understood visually. For the **Pressure Graphs**, the system merges the Date and Time columns into a single datetime object. To make the graph readable, we don't plot the whole day. We filter the data to a specific window: **T-40 minutes to T+10 minutes** around the launch. The code iterates through the sensor columns (Headers and Pivots) and plots them. We also implemented **Smart Axis Formatting**, which snaps the Y-axis limits to the nearest 20-bar step, making the charts clean and professional."

+2

Slide 10: Boom Angle Graph "Perhaps the most complex visualization is the **Boom Angle Graph**. This graph overlays the movement of the LOX arm and the LH2 arm on a single timeline. The system reads two separate sheets from the Excel file, detects the 'Angle' and 'Time' columns dynamically, and overlays them. As you can see in the logic, the LOX arm is plotted as a **Solid Red Line**, and the LH2 arm is a **Dashed Blue Line**. This allows engineers to instantly see if the arms are retracting synchronously."

+2

Outputs & Conclusion (7:00 – 9:00)

Slide 11 & 12: Outputs (GSLV & LVM3) "The result of all this processing is shown here. Whether it is the GSLV Mark II or the LVM3, the system generates a standardized, high-resolution report containing all the tables and graphs we just discussed."

Slide 13: Technologies Used "To summarize the Tech Stack:

- **Python** was the core language.
- **Pandas** handled the heavy lifting of data processing.
- **Matplotlib** served as our plotting engine.
- **Tkinter** provided the user interface.
- **ReportLab** was crucial for programmatically building the PDF layout.
- **Regex** ensured we could handle inconsistent column names in the raw logs."

Slide 14: Impact & Benefits "The impact of this automation is significant:

1. **Efficiency:** We have reduced the analysis turnaround time from **hours to mere seconds**.
2. **Accuracy:** By removing manual data entry, we have eliminated the risk of human transcription errors.
3. **Standardization:** It produces an instant, industry-standard report every single time.

This project represents a leap forward in the digital transformation of Ground Support Equipment analysis."

Slide 15: Thank You "I would like to thank ISRO and specifically my guide Mr. K. Murali for this opportunity. I am now open to any questions you may have regarding the logic or implementation. Thank you.

I saw your PPT content. Here's a **ready-to-present speech script** based on your slides. This is written to take **6–10 minutes** (≈ 900–1300 words). You can read or memorize it.

I've made it natural, simple, and technical enough for ISRO/project evaluation.

🎤 **Presentation Speech – Project (6–10 mins)**

Slide 1 — Introduction

Good morning/afternoon everyone.

I am **C Dhiya**, pursuing B.Tech in Computer Science with specialization in AI and Machine Learning. I completed this project under the guidance of **Mr. K. Murali, Engineer – SF at Satish Dhawan Space Centre, ISRO**, during January to February 2026.

My project is titled **"Cryogenic System Dynamics and Vehicle Interface Analysis for GSLV and LVM3 Vehicles."**

This project focuses on analyzing cryogenic control systems used in launch operations and developing a Python-based automation tool to improve post-mission analysis efficiency.

Slide 2 — Project Introduction

The cryogenic control system plays a critical role in rocket launch infrastructure. It manages the supply of **Liquid Oxygen (LOX)** and **Liquid Hydrogen (LH2)** to the launch vehicle.

For mission safety and performance validation, multiple systems must be monitored, including:

- Intelligent Control System performance
- Accumulator charging systems
- Cryogenic arm retraction dynamics

Traditionally, analyzing telemetry data from these systems takes significant manual effort.

So in this project, I developed a **Python-based automation suite** that processes high-frequency telemetry data from Excel logs, maps system events, analyzes pressure cycles, and visualizes system behavior.

The system uses:

- Pandas for data processing
- Matplotlib for visualization
- Automated logic for event detection

This helps engineers analyze launch data faster and more accurately.

Slide 3 — Datasets Used

The project uses telemetry datasets from:

- **Mark II (GSLV)**
- **Mark III (LVM3)**

Each contains multiple datasets including:

- Timestamped telemetry values
- LOX and LH2 pressure measurements
- Accumulator charging and discharging data
- Cryogenic arm boom position
- UCU separation event timings

These datasets represent real operational parameters recorded during launch sequences.

Slide 4 — System Architecture

The system architecture includes several stages:

- User input through GUI
- Data preprocessing
- Validation
- Event analysis
- Graph generation
- Report generation

The system processes raw cryogenic data and produces structured outputs and visual reports.

Slide 5 — Input and Data Preprocessing

First, the system accepts user input through a **Tkinter-based GUI**.

The user uploads Excel files and provides:

- Event date
- Event time

The system then reads Excel files using Pandas and converts raw data into structured dataframes.

It performs:

- File validation to ensure input exists
- Column validation by normalizing names
- Date-time validation for correct format

This ensures data consistency before processing.

Slide 6 — Table 1: Accumulator Charging

The first analysis table captures the system state at specific countdown milestones like:

- T minus 20 minutes
- T minus 10 minutes

The system calculates these times using the launch time provided by the user.

It then performs a **nearest neighbor search** to find the closest timestamp in the dataset and extracts pressure values such as header and pivot pressures.

This helps evaluate accumulator readiness during critical launch stages.

Slide 7 — Table 2: Accumulator Charging Timings

The second table maps cyclic charging and discharging events.

The system:

- Reads charging and discharging times
- Maps them to predefined pressure steps
- Sequentially fills data based on charging or discharging state

It also converts raw PLC time values into readable time format.

This allows engineers to verify whether pressure cycles follow expected patterns.

Slide 8 — Table 3: Cryo Arm Data After Retraction

This table captures system snapshots during cryogenic arm retraction.

It includes:

- Pressure values
- Retraction angles
- Timer values

The system converts PLC timer values into standard time format and scales pressure values appropriately.

This helps analyze boom movement dynamics and verify safe detachment of the cryogenic arm.

Slide 9 — Pressure Graphs

The system also generates pressure graphs for LOX and LH2.

It visualizes pressure trends for multiple sensors over a specific launch window from **T minus 40 minutes to T plus 10 minutes**.

The system:

- Combines date and time columns
- Filters relevant data
- Plots multiple sensor values
- Adjusts axis limits dynamically

This provides clear visualization of pressure behavior during launch operations.

Slide 10 — Boom Angle Graph

Another important visualization is the boom angle graph.

The system reads LOX and LH2 data from separate sheets and compares their physical movement.

- LOX is plotted as a solid line
- LH2 is plotted as a dashed line

The graph shows arm movement over time and helps analyze synchronization between systems.

Slide 11 — Generated Outputs

The system automatically generates structured outputs and final reports for:

- GSLV analysis
- LVM3 analysis

All results are compiled into a professional PDF format.

Slide 12 — Technologies Used

This project uses multiple technologies:

- **Python** for automation
- **Pandas** for data processing
- **Matplotlib** for visualization
- **Tkinter** for GUI
- **ReportLab** for PDF generation
- **OpenPyXL** for Excel reading
- **Datetime module** for temporal calculations

- **Regex** for column normalization

Together, these tools enable automated data analysis and reporting.

Slide 13 — Impact and Benefits

This system provides several benefits:

- Instant automated reporting
- Reduction in analysis time from hours to seconds
- Elimination of human transcription errors
- Improved accuracy in mission validation
- Contribution to digital transformation of ground support equipment analysis

Overall, the project improves efficiency and reliability in cryogenic system evaluation.

Slide 14 — Conclusion

To conclude, this project successfully developed an automated solution for analyzing cryogenic system dynamics and vehicle interface data for GSLV and LVM3 vehicles.

The system improves data processing efficiency, enhances visualization, and enables faster decision-making in launch operations.

This work demonstrates how AI and automation techniques can support space mission infrastructure and operational analysis.

Thank you.

✅ 1. What is a cryogenic system?

Answer:
A cryogenic system handles substances at extremely low temperatures, usually below −150°C. In space launch vehicles, it stores and supplies cryogenic fuels like liquid oxygen and liquid hydrogen to the rocket engine.

✅ 2. Why are cryogenic fuels used in rockets?

Answer:
Cryogenic fuels provide very high energy efficiency and higher thrust. Liquid hydrogen and liquid oxygen produce high specific impulse, making them ideal for space missions.

✅ 3. What are LOX and LH2?

Answer:

- **LOX (Liquid Oxygen)** → oxidizer stored at about −183°C
- **LH2 (Liquid Hydrogen)** → fuel stored at about −253°C

They react to produce thrust in rocket engines.

✅ 4. Why must cryogenic fuels be stored at very low temperatures?

Answer:
These fuels exist in liquid form only at extremely low temperatures. If temperature increases, they evaporate and pressure rises, which can be dangerous.

✅ 5. Why is pressure monitoring important in cryogenic systems?

Answer:
Pressure ensures proper fuel flow and system stability. Incorrect pressure can cause engine failure, leakage, or explosion risk.

⭐ SYSTEM WORKING QUESTIONS

✅ 6. What is the cryogenic control system in launch infrastructure?

Answer:
It controls storage, pressure regulation, and supply of cryogenic fuels to the launch vehicle and ensures safe operation before and during launch.

✅ 7. What happens if cryogenic fuel pressure is unstable?

Answer:
It may affect engine combustion, reduce thrust efficiency, or cause system failure, leading to mission risk.

✅ 8. What is cryogenic arm retraction?

Answer:
It is the process of removing fuel supply arms from the rocket before launch. This ensures the rocket is disconnected safely.

✅ 9. Why is arm retraction analysis important?

Answer:
Improper retraction may damage the vehicle or interrupt launch operations.

✅ **10. What parameters are monitored in cryogenic systems?**

Answer:

- Pressure
- Temperature
- Flow rate
- Valve timing
- Boom position
- Charging cycles

⭐ **ACCUMULATOR & PRESSURE QUESTIONS**

✅ **11. What is an accumulator?**

Answer:
An accumulator stores pressurized fluid and maintains pressure stability in the system.

✅ **12. Why is accumulator charging analysis required?**

Answer:
It ensures the system maintains required pressure levels during critical launch stages.

✅ **13. What is charging and discharging cycle?**

Answer:
Charging increases pressure in the system, and discharging releases stored pressure to maintain stability.

✅ **14. What happens if accumulator fails?**

Answer:
Pressure instability may occur, affecting fuel supply and launch safety.

⭐ **ROCKET ENGINE RELATED QUESTIONS**

✅ **15. How does LOX and LH2 produce thrust?**

Answer:
Liquid hydrogen burns with liquid oxygen in the combustion chamber, producing high-temperature gases that exit through the nozzle to generate thrust.

✅ **16. Why is LH2 preferred as rocket fuel?**

Answer:
It has very high energy per unit mass and produces efficient combustion.

✅ **17. What is specific impulse?**

Answer:
Specific impulse measures rocket engine efficiency. Higher specific impulse means better fuel efficiency.

(Nice bonus answer — impresses panel)

⭐ **SAFETY QUESTIONS (Common in ISRO viva)**

✅ **18. What are challenges in handling cryogenic fuels?**

Answer:

- Extremely low temperatures
- Material brittleness
- Pressure buildup
- Leakage risks
- Complex storage requirements

✅ **19. Why is cryogenic fuel handling dangerous?**

Answer:
Rapid evaporation can cause pressure explosion, and extremely low temperature can damage materials.

✅ **20. How is safety ensured in cryogenic systems?**

Answer:
By monitoring pressure, temperature, valve operation, and system behavior continuously.

⭐ **PROJECT-SPECIFIC CRYOGENIC QUESTIONS (Very Important)**

✅ **21. What cryogenic parameters did your project analyze?**

Answer:
My project analyzed LOX and LH2 pressure values, accumulator charging cycles, and cryogenic arm boom movement.

✅ **22. How does your project help cryogenic system monitoring?**

Answer:
It automates data analysis, visualizes pressure trends, and detects system behavior during launch operations.

✅ **23. Why did you analyze pressure vs time graphs?**

Answer:
To understand system stability and identify abnormal pressure variations during launch.

✅ **24. Why analyze T-minus time events?**

Answer:
Critical operations occur at specific countdown times, so system status must be verified.

⭐ **ADVANCED QUESTIONS (If panel is strict)**

✅ **25. Why is LH2 harder to store than LOX?**

Answer:
LH2 requires much lower temperature and has very low density, making storage and handling more complex.

✅ **26. What materials are used in cryogenic systems?**

Answer:
Special materials like stainless steel or aluminum alloys are used because they withstand low temperatures.

✅ **27. What is boil-off in cryogenic storage?**

Answer:
Boil-off is evaporation of cryogenic liquid due to heat leakage.

✅ **28. Difference between cryogenic and non-cryogenic fuels?**

Answer:
Cryogenic fuels require extremely low temperature storage, while non-cryogenic fuels can be stored at room temperature.