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CS 3331 – Advanced Object-Oriented Programming – Spring 2025

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Assignment – Project Part 2 Lab Report

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## **1. Program Explanation**

In part two of the Space Debris Project, we enhanced our previous implementation to support full functionality for all user roles: Scientist, Space Agency Representative, Policymaker, and Administrator, while also using OOP programming practices learned in class.

To tackle this project, we first fixed some major issues from Part 1 and ensured the system handled more flexible input formats, such as differently formatted CSV input files. We divided our codebase into modules, and applied design patterns like the Strategy Pattern to handle report generation. We split the functionality by user roles and added login authentication and the ability to manage users. Breaking the overall system into well-defined modules such as MissionControl, ImpactAnalysis, UserManager helped us approach the problem more easily.

## **2. What did we learn?**

Through this project, we gained a deeper understanding of how to build scalable, role-based applications using object-oriented principles. We learned how to refactor a program into reusable components and handle practical file processing tasks like dynamic CSV parsing.

Our solution could be improved by adding a graphical user interface. A different approach could involve separating data access logic from business logic entirely. This project took us 2 weeks to complete, including debugging, refactoring, and implementing new functionality for all users.

## **3. Solution Design**

We approached the problem by separating the functionality into roles and using object-oriented programming to delegate responsibilities across specific classes. We used `List<SpaceObject>` to store debris and satellites in memory for efficient iteration and analysis. We also used `Map<String, Integer>` to support flexible CSV header indexing. The program assumes that the CSV files are syntactically valid, but accounts for unordered headers and missing fields. Each feature (such as tracking, orbit assessment, density reporting, and user management) was implemented as a standalone module to keep it clear and maintainable.

## 4. Testing

We applied both black-box and white-box testing strategies. For black-box testing, we ran the program as an end user would, validating each menu interaction and file output. For white-box testing, we wrote unit tests for key methods like `verifyLogin()`, `assessAndSave()`, and report generators using JUnit.

We tested edge cases such as:

- Invalid CSV headers
- Users entering incorrect login credentials
- Missing files (e.g., no `users.csv` or `orbit status` file)
- Boundary values in longitude filtering

We intentionally (and accidentally) broke the program at times , like removing CSV columns or entering bad input to ensure correctness and then fixed issues based on those tests.

## 5. Test results

The test results confirmed that all core features work as expected:

- Orbit assessments output updated CSV and TXT reports
- Density reports accurately count object types by orbit or longitude
- All user login roles are verified correctly
- Admin can create, view, update, and delete users
- Console menus remain intuitive and prevent invalid input

## 6. Code Review

The code successfully fulfills all intended functionalities for each user role, with a modular and maintainable design that uses dynamic input handling, such as flexible CSV parsing. Logic flows are good and tested across edge cases, with correct validation and error handling. The code is well-structured, readable, and maintainable. We stuck closely to object-oriented principles. Performance is efficient for the expected data scale, with most operations running in linear time. Overall, the implementation is sound, readable, maintainable, and meets both functional and realistic expectations.

```

=== User Type Menu ===
1. Scientist
2. Space Agency Rep
3. Policymaker
4. Administrator
5. Exit
Enter choice: 1
Username: alice
Password: pass123

--- Scientist Menu ---
1. Track Objects in Space
2. Assess Orbit Status
3. Back
Choice: █

```

```

--- Track Objects Menu ---
1. Rocket Body
2. Debris
3. Payload
4. Unknown
5. Back
Select an option: 2

--- Tracking: DEBRIS ---
10436, COSMOS 839 DEB, CIS, LEO, 1976, PKMTR, 29.39840935, -32.93402367, "62.925556, 17741
12529, DELTA 1 DEB, US, LEO, 1976, AFWTR, -49.97556469, 63.24844584, "34.742221, 17720
21249, SL-8 DEB, CIS, LEO, 1991, PKMTR, -162.5254582, -98.07395074, "62.925556, 12409
26005, SL-14 DEB, CIS, LEO, 1991, PKMTR, 9.339711283, 22.61155748, "62.925556, 12181
29210, SCOUT G-1 DEB, US, LEO, 1987, AFWTR, 0.0, 0.0, "34.742221, 13654
29539, CZ-4B DEB, PRC, LEO, 2006, TSC, 26.25180283, 127.1089658, "38.849086, 6857
31518, FENGYUN 1C DEB, PRC, LEO, 1999, TSC, 0.0, 0.0, "38.849086, 9400
32558, DELTA 4H DEB, US, Unknown Orbit Category, 2007, AFETR, 0.0, 0.0, "28.4917337, 6293
35350, PSLV DEB, IND, LEO, 2001, SRI, -19.90037801, 94.22048479, "13.7178, 8504
35670, COSMOS 2251 DEB, CIS, LEO, 1993, PKMTR, 39.99585443, 50.95457541, "62.925556, 11554
39350, CZ-3C DEB, PRC, HEO, 2010, XSC, -133.5762562, -101.9103117, "28.246017, 5208
39645, COSMOS 1867 COOLANT, CIS, LEO, 1987, TTMTR, 142.5517496, 26.19027854, "45.965, 13722
46525, FREGAT DEB, CIS, LEO, 2011, TTMTR, 0.0, 0.0, "45.965, 4948
4821, THORAD AGENA D DEB, US, LEO, 1970, AFWTR, 178.2103203, -72.04940003, "34.742221, 20024
50802, COSMOS 2499 DEB, CIS, LEO, 2014, PKMTR, 0.0, 84.37778856, "62.925556, 3908
61354, CZ-6A DEB, PRC, LEO, 2024, TSC, 0.0, 32.2282236, "38.849086, 180
61819, CZ-6A DEB, PRC, LEO, 2024, TSC, 0.0, 22.59503966, "38.849086, 180
12542, DELTA 1 DEB, US, LEO, 1976, AFWTR, -32.49004766, 127.1862917, "34.742221, 17720
21453, DELTA 1 DEB, US, LEO, 1975, AFWTR, 136.6945894, -145.4078904, "34.742221, 18133
23479, SL-19 DEB, CIS, LEO, 1994, TTMTR, 164.320848, 35.19114769, "45.965, 10996
26222, CZ-4 DEB, PRC, LEO, 1999, TSC, -158.5481305, -177.5567996, "38.849086, 9243
27729, DELTA 1 DEB, US, LEO, 1977, AFETR, 156.6135471, -46.53318009, "28.4917337, 17370
28039, ARIANE 44L DEB, FR, HEO, 1991, FRGUI, -109.6053068, 33.16837829, "5.222222, 12437
30750, FENGYUN 1C DEB, PRC, LEO, 1999, TSC, -131.0859727, 149.0198411, "38.849086, 9400
38296, CZ-4C DEB, PRC, LEO, 2010, TSC, -91.65614593, -30.67934984, "38.849086, 5204

```

```

--- Administrator Menu ---
1. Create User
2. View Users
3. Manage Users
4. Delete User
5. Back
1
Enter username: adonis
Enter role (Scientist, Admin, Agency, Policymaker): Agency
User created successfully.

--- Administrator Menu ---
1. Create User
2. View Users
3. Manage Users
4. Delete User
5. Back

```

```

--- Space Agency Representative Menu ---
1. Analyze Long-term Impact
2. Generate Density Reports
3. Full Report
4. Back
Choice: 1

--- Debug: Evaluating LEO objects ---

--- Long-Term Impact Report (LEO > 200 days + conjunctions) ---
Record ID: 47880, Name: STARLINK-2337, Country: US, Orbit Type: LEO, Object Type: PAYLOAD, Days Old: 1421, Conjunctions: 11
Record ID: 48370, Name: STARLINK-2621, Country: US, Orbit Type: LEO, Object Type: PAYLOAD, Days Old: 1370, Conjunctions: 12
Record ID: 54008, Name: STARLINK-5145, Country: US, Orbit Type: LEO, Object Type: PAYLOAD, Days Old: 851, Conjunctions: 4
Record ID: 55658, Name: STARLINK-5307, Country: US, Orbit Type: LEO, Object Type: PAYLOAD, Days Old: 716, Conjunctions: 6
Record ID: 57868, Name: STARLINK-30442, Country: US, Orbit Type: LEO, Object Type: PAYLOAD, Days Old: 505, Conjunctions: 6
Record ID: 58185, Name: STARLINK-30793, Country: US, Orbit Type: LEO, Object Type: PAYLOAD, Days Old: 461, Conjunctions: 8
Record ID: 58197, Name: STARLINK-30762, Country: US, Orbit Type: LEO, Object Type: PAYLOAD, Days Old: 461, Conjunctions: 2
Record ID: 60053, Name: STARLINK-31793, Country: US, Orbit Type: LEO, Object Type: PAYLOAD, Days Old: 239, Conjunctions: 7
Record ID: 50832, Name: STARLINK-3328, Country: US, Orbit Type: LEO, Object Type: PAYLOAD, Days Old: 1123, Conjunctions: 15
Record ID: 54073, Name: STARLINK-5146, Country: US, Orbit Type: LEO, Object Type: PAYLOAD, Days Old: 836, Conjunctions: 8
Record ID: 56199, Name: TOMORROW-R1, Country: US, Orbit Type: LEO, Object Type: PAYLOAD, Days Old: 659, Conjunctions: 5
Record ID: 56505, Name: STARLINK-5763, Country: US, Orbit Type: LEO, Object Type: PAYLOAD, Days Old: 630, Conjunctions: 1
Record ID: 56539, Name: STARLINK-6135, Country: US, Orbit Type: LEO, Object Type: PAYLOAD, Days Old: 630, Conjunctions: 1
Record ID: 59264, Name: STARLINK-31645, Country: US, Orbit Type: LEO, Object Type: PAYLOAD, Days Old: 320, Conjunctions: 2
Record ID: 11667, Name: COSMOS 1150, Country: CIS, Orbit Type: LEO, Object Type: PAYLOAD, Days Old: 16456, Conjunctions: 4
Record ID: 51789, Name: STARLINK-3639, Country: US, Orbit Type: LEO, Object Type: PAYLOAD, Days Old: 1073, Conjunctions: 17
Record ID: 53223, Name: STARLINK-4354, Country: US, Orbit Type: LEO, Object Type: PAYLOAD, Days Old: 926, Conjunctions: 6
Record ID: 54010, Name: STARLINK-5127, Country: US, Orbit Type: LEO, Object Type: PAYLOAD, Days Old: 851, Conjunctions: 8
Record ID: 54198, Name: STARLINK-5246, Country: US, Orbit Type: LEO, Object Type: PAYLOAD, Days Old: 828, Conjunctions: 10
Record ID: 56413, Name: STARLINK-6258, Country: US, Orbit Type: LEO, Object Type: PAYLOAD, Days Old: 640, Conjunctions: 5
Record ID: 57329, Name: STARLINK-6138, Country: US, Orbit Type: LEO, Object Type: PAYLOAD, Days Old: 567, Conjunctions: 9
Record ID: 58639, Name: STARLINK-31070, Country: US, Orbit Type: LEO, Object Type: PAYLOAD, Days Old: 407, Conjunctions: 12

--- Space Agency Representative Menu ---
1. Analyze Long-term Impact
2. Generate Density Reports
3. Full Report
4. Back
Choice: █

```