Student Name	**Songyan Lai**	**Student Number**	**24250371**
Supervisor	**Rosemary Monahan**	**ECTS Credits**	**15**
Project Title	**Integrating FRET and WEST**		

1) Overall Project Objectives.

This research focuses on integrating FRET and WEST to enhance requirements traceability. FRET, developed by NASA's Software Verification and Validation team and further refined by my supervisor's team into MU-FRET. Meanwhile, the WEST tool supports the validation of Mission-time Linear Temporal Logic (MLTL) formulas by generating corresponding regular expressions. The primary objectives include a detailed examination of FRET, WEST, and related Linear Temporal Logic frameworks alongside mainstream formal verification tools. This analysis underpins the necessity of integrating FRET and WEST while also identifying limitations within the WEST tool. A significant focus is on developing an interconversion process between LTL and MLTL that ensures compatibility with WEST's syntax, enabling accurate and effective tool integration.

2) Description of work completed.

1. Study of Temporal Logic Variants: Conducted an in-depth study of Linear Temporal Logic (LTL), Future Time LTL, Past Time LTL, Metric Temporal Logic (MTL), and Mission Time LTL (MLTL). Summarized their similarities and differences in a well-documented comparative analysis.
2. Research on FRET and WEST: Conducted a comprehensive study of both tools, culminating in a 7,000-word essay titled "The Motivation for Integration of WEST and FRET." This paper highlights the benefits of integration, including improved traceability, enhanced verification efficiency, and stakeholder collaboration.
3. Critical Analysis of WEST Syntax: During the integration process, identified discrepancies between the expected and accepted syntax of the WEST tool. This discovery led to critical research and the completion of an 8,000-word essay, "Exploring the Role of WEST in Temporal Logic Validation: Strengths, Limitations, and Extensions." This paper analyzes WEST's capabilities compared to other formal verification tools, proposes improvements, and explores strategies for broader integration.
4. Development of a Syntax Converter: Implemented an initial version of a syntax converter using JavaScript and HTML. This converter facilitates the translation of FRET-generated syntax into WEST-compatible formats. The project involved several iterative improvements, with the current codebase exceeding 200 lines.

2.1) Evidence of work completed.

1. Code Implementation: A 200+ line syntax converter written in JavaScript and HTML, complete with multiple iterations to enhance functionality.
2. Documentation: Two in-depth essays (7,000 words and 8,000 words) analyzing the integration of FRET and WEST, and critical assessments of WEST's current limitations and recommendations for enhancement.

2.2) Literature review.

1. Temporal Logic Frameworks: Foundational work by Pnueli (1977) on LTL, along with subsequent extensions like MLTL, forms the theoretical core. Rozier (2020) and Elwing et al. (2023) emphasize the relevance of MLTL in mission-critical systems.
2. FRET and MU-FRET Tools: NASA's FRET provides formalization of requirements, while Maynooth University's MU-FRET improves usability for safety-critical contexts.
3. WEST Tool: Elwing et al. (2024) explore WEST's strengths and limitations in validating MLTL formulas, particularly highlighting the need for syntax flexibility, which this project addresses.
4. Comparative Studies: Insights from technical analyses of formal verification tools shaped the integration design, ensuring the solution aligns with existing workflows.

2.3) Use of GenAI and tools.

1. Research Assistance: Used GenAI to efficiently locate and summarize relevant literature, ensuring a comprehensive understanding of temporal logic frameworks and verification tools.
2. Language Translation: Utilized GenAI for accurate and efficient English-Chinese translations to facilitate communication and documentation.
3. Code Debugging: Leveraged GenAI to identify and resolve bugs in the syntax converter.

3) Future work.

1. Enhancing the Syntax Converter: Conduct rigorous testing and iterative improvements to expand the converter's functionality. Focus will be placed on making the tool more intuitive and user-friendly, ensuring a seamless experience for users with varying technical expertise.
2. Analyzing and Addressing Limitations in WEST: Perform a detailed analysis of the limitations of the WEST tool, identifying critical areas for improvement. Efforts will be directed toward proposing and implementing potential solutions to enhance its usability, flexibility, and compatibility with other tools.
3. Case Study on FRET-to-WEST Conversion: Conduct a detailed case study to evaluate the translation process from FRET to WEST. This analysis will focus on identifying potential losses as well as gains. The findings will highlight the practical trade-offs of the integration process.
4. Exploration and Recommendations for Broader Integration: Expand the scope of research to include the exploration of additional formal verification tools, such as R2U2, and alternative requirement formalization languages like SALT, EARS, and DOORS. Comparative analyses will assess their strengths and weaknesses, and provide critical insights and recommendations for future developments, contributing to the long-term goal of creating a more cohesive and versatile verification ecosystem.

Appendix - Additional Evidence

All files related to this project have been uploaded to my personal channel on the university's GitLab repository, accessible at https://gitlab.cs.nuim.ie/u250731/integrating-fret-and-west. The following sections outline the key resources and their organization within the repository:

1. **FRET_to_WEST_MLTL_Converter Folder**
   - **Code Implementation**: Contains the beta version of a syntax converter, a JavaScript and HTML implementation exceeding 200 lines. This tool has undergone multiple iterations to improve its functionality and usability.
   - **Testing and Iterations**: Includes additional code files generated during the testing and refinement process, demonstrating the progression and iterative enhancements made throughout development.
   -
2. **My Research Papers Folder**
   - **The Motivation for Integration of WEST and FRET**: A research paper of approximately 7,000 words, highlighting the motivations for integrating FRET and WEST. It focuses on the benefits of this integration, including improved requirements traceability, enhanced verification efficiency, user-friendliness, and stakeholder collaboration.
   - **Exploring the Role of WEST in Temporal Logic Validation: Strengths, Limitations, and Extensions**: An 8,000+ word paper providing a critical assessment of the WEST tool. This work evaluates its strengths and limitations in validating Mission-Time Linear Temporal Logic (MLTL) formulas and proposes potential improvements and strategies for further integration.
3. **Weekly Reports Folder**
   - Contains weekly project reports documenting progress, challenges, and resolutions. This includes communication records with my supervisor, which provide insights into the iterative decision-making process.
   - Features additional documents compiled during my research, including summaries, analyses, and other related materials that contributed to the project's development.