

# DR AZALEA RAAD

Director of the UK Research Institute on Verified Trustworthy Software Systems ([VeTSS](#))  
(last updated: April 2025)

Reader and UKRI Future Leader Fellow  
Imperial College London, Department of Computing  
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## EMPLOYMENT

### Department of Computing, Imperial College London

- Reader July 2024 – Present
- Senior Lecturer July 2022 – June 2024
- Lecturer April 2020 – June 2022

**Consultant at Bloomberg, London**  
Chief Technical Office

**September 2022 – Present**

**Consultant at Meta AI, London**  
(to commence)

**September 2025 – July 2027**

**Consultant at Meta (formerly Facebook), London**  
Infer Verification Team and Incorrectness Logic Lab

**September 2020 – July 2022**

**Postdoctoral Researcher at MPI-SWS**  
Group: Programming Languages and Verification (PLV)  
Managers: Derek Dreyer and Viktor Vafeiadis

**July 2017 – March 2020**

## EDUCATION

**PhD in Theoretical Computer Science**  
Imperial College London

**October 2010 – December 2016**

Thesis: *Abstraction, Refinement and Concurrent Reasoning*

Supervisors: Philippa Gardner and Sophia Drossopoulou

Examiners: Derek Dreyer (MPI-SWS) and Matthew Parkinson (Microsoft Research)

**Master of Engineering in Computer Science**

**October 2006 – June 2010**

Imperial College London, graduated third in class with a First Class Honours Degree

Thesis title: *Smelling of Roses (ROles - Specification, Exploration, Scrutiny)*

Supervisors: Sophia Drossopoulou and Susan Eisenbach

🏆 **Winner of the Corporate Partnership Prize**

## GRANTS AND FUNDING

**[F1] Principal Investigator**

**September 2024 – August 2026**

Grant from Defence Advanced Research Projects Agency (DARPA, US)

Project Title: *Proof of Bugs for All*

Amount: \$750,000 (~£600,000)

<b>[F2] Principal Investigator</b> EPSRC Standard Grant Project Title: <i>SACRED-MA: Safe and Secure Remote Direct Memory Access</i> Amount: £750,000	<b>September 2023 – August 2026</b>
<b>[F3] International PhD Studentship</b> Sponsored by Bloomberg Amount: £120,000	<b>September 2023 – August 2027</b>
<b>[F4] Industrial Case (iCASE) PhD Studentship</b> Sponsored by ARM Amount: £35,000	<b>October 2023 – September 2027</b>
<b>[F5] Co-Director</b> Directorship of the UK Research Institute Verified Trustworthy Software Systems (VeTSS) Amount: £750,000	<b>December 2022 – November 2026</b>
<b>[F6] Principal Investigator</b> Research Gift by Meta Amount: \$50,000 (~£40,000)	<b>October 2022 – September 2023</b>
<b>[F7] Sole Investigator</b> UKRI Future Leader Fellowship Project Title: <i>PERSEVERE: A Rigorous Foundation for Persistent Verification</i> Amount: £1,500,000	<b>October 2021 – September 2028</b>
<b>[F8] Principal Investigator</b> UKRI VeTSS (UK Research Institute in Verified Trustworthy Software Systems) Project Title: <i>Validating the Foundations of Verified Persistent Programming</i> Amount: £100,000	<b>April 2020 – March 2021</b>
<b><u>Funding Total: £3,895,000</u></b>	

## PUBLICATIONS

- [P1]** *Non-Termination Proving: 100 Million LoC and Beyond*  
Julien Vanegue, Peter O’Hearn, **Azalea Raad**  
Computer-Aided Verification (CAV), 2025  
**Conference Paper** (Rank: A\*)
- [P2]** *Sufficient Conditions for Robustness of RDMA Programs*  
Guillaume Ambal, Ori Lahav, **Azalea Raad**  
European Symposium on Programming (ESOP), 2025  
**Conference Paper** (Rank: A)
- [P3]** *Compositional Bug Detection for Internally Unsafe Libraries*  
Pedro Carrott, Sacha-E’lie Ayoun, **Azalea Raad**  
European Conference on Object-Oriented Programming (ECOOP), 2025  
**Conference Paper** (Rank: A)

- [P4] *IsaBIL: A Framework for Verifying (In)correctness of Binaries in Isabelle/HOL*  
 Matt Griffin, Brijesh Dongol, **Azalea Raad**  
 European Conference on Object-Oriented Programming (ECOOP), 2025  
[Conference Paper](#) (Rank: A)
- [P5] *Non-Termination Proving at Scale*  
**Azalea Raad**, Julien Vanegue, Peter O’Hearn  
 Object-Oriented Programming, Systems, Languages, and Applications (OOPSLA), 2024  
[Journal Paper](#), [Conference Paper](#) (Rank: A\*)
- [P6] *Semantics of Remote Direct Memory Access: Operational and Declarative Models of RDMA on TSO Architectures*  
 Guillaume Ambal, Brijesh Dongol, Haggai Eran, Vasileios Klimis, Ori Lahav, **Azalea Raad**  
 Object-Oriented Programming, Systems, Languages, and Applications (OOPSLA), 2024  
[Journal Paper](#), [Conference Paper](#) (Rank: A\*)
- [P7] *Extending the C/C++ Memory Model with Inline Assembly*  
 Paulo Emílio de Vilhena, Ori Lahav, Viktor Vafeiadis, **Azalea Raad**  
 Object-Oriented Programming, Systems, Languages, and Applications (OOPSLA), 2024  
[Journal Paper](#), [Conference Paper](#) (Rank: A\*)
- [P8] *Specifying and Verifying Persistent Libraries*  
 Léo Stefanescu, **Azalea Raad**, Viktor Vafeiadis  
 European Symposium on Programming (ESOP), 2024  
[Conference Paper](#) (Rank: A)
- [P9] *Intel PMDK Transactions: Specification and Concurrency*  
**Azalea Raad**, Ori Lahav, John Wickerson, Brijesh Dongol  
 European Symposium on Programming (ESOP), 2024  
[Conference Paper](#) (Rank: A)
- [P10] *Challenges in Empirically Testing Memory Persistency Models*  
 Vasileios Klimis, Alastair F. Donaldson, Viktor Vafeiadis, John Wickerson, **Azalea Raad**  
 International Conference on Software Engineering (ICSE), 2024  
[Conference Paper](#) (Rank: A\*)
- [P11] *A General Approach to Under-approximate Reasoning about Concurrent Programs*  
**Azalea Raad**, Julien Vanegue, Josh Berdine, Peter O’Hearn  
 Conference on Concurrency Theory (CONCUR), 2023  
[Conference Paper](#) (Rank: A)
- [P12] *Memento: A Framework for Detectable Recoverability in Persistent Memory*  
 Kyeongmin Cho, Seungmin Jeon, **Azalea Raad**, Jeehoon Kang  
 Programming Language Design and Implementation (PLDI), 2023  
[Journal Paper](#), [Conference Paper](#) (Rank: A\*)
- [P13] *The Path to Durable Linearizability*  
 Emanuele D’Osualdo, **Azalea Raad**, Viktor Vafeiadis  
 Principles of Programming Languages (POPL), 2023  
[Journal Paper](#), [Conference Paper](#) (Rank: A\*)

- [P14] *Finding Real Bugs in Big Programs with Incorrectness Logic*  
 Quang Loc Le, **Azalea Raad**, Jules Villard, Josh Berdine, Derek Dreyer, Peter O’Hearn  
 Object-Oriented Programming, Systems, Languages, and Applications (OOPSLA), 2022  
 🏆 **Winner of the distinguished paper award**  
**Journal Paper**, **Conference Paper** (Rank: A\*)
- [P15] *View-Based Owicki-Gries Reasoning for Persistent x86-TSO*  
 Eleni Vafeiadi Bila, Brijesh Dongol, Ori Lahav, **Azalea Raad**, John Wickerson  
 European Symposium on Programming (ESOP), 2022  
 🏆 **Winner of the distinguished artifact award**  
**Conference Paper** (Rank: A)
- [P16] *Concurrent Incorrectness Separation Logic*  
**Azalea Raad**, Josh Berdine, Derek Dreyer, Peter O’Hearn  
 Principles of Programming Languages (POPL), 2022  
**Journal Paper**, **Conference Paper** (Rank: A\*)
- [P17] *Extending Intel-x86 Consistency and Persistency: Formalising the Semantics of Intel-x86 Memory Types and Non-Temporal Stores*  
**Azalea Raad**, Luc Maranget, Viktor Vafeiadis  
 Principles of Programming Languages (POPL), 2022  
**Journal Paper**, **Conference Paper** (Rank: A\*)
- [P18] *Revamping Hardware Persistency Models*  
 Kyeongmin Cho, Sung-Hwan Lee, **Azalea Raad**, Jeehoon Kang  
 Programming Language Design and Implementation (PLDI), 2021  
**Journal Paper**, **Conference Paper** (Rank: A\*)
- [P19] *PerSeVerE: Persistency Semantics for Verification under Ext4*  
 Michalis Kokologiannakis, Ilya Kaysin, **Azalea Raad**, Viktor Vafeiadis  
 Principles of Programming Languages (POPL), 2021  
**Journal Paper**, **Conference Paper** (Rank: A\*)
- [P20] *Persistent Owick-Gries Reasoning*  
**Azalea Raad**, Ori Lahav, Viktor Vafeiadis  
 Object-Oriented Programming, Systems, Languages, and Applications (OOPSLA), 2020  
**Journal Paper**, **Conference Paper** (Rank: A\*)
- [P21] *Local Reasoning about the Presence of Bugs: Incorrectness Separation Logic*  
**Azalea Raad**, Josh Berdine, Hoang-Hai Dang, Derek Dreyer, Peter O’Hearn, Jules Villard  
 Computer-Aided Verification (CAV), 2020  
**Conference Paper** (Rank: A\*)
- [P22] *Data Consistency in Transactional Storage Systems: A Centralised Approach*  
 Shale Xiong, Andrea Cerone, **Azalea Raad**, Philippa Gardner  
 European Conference on Object-Oriented Programming (ECOOP), 2020  
**Conference Paper** (Rank: A)
- [P23] *Persistency Semantics of the Intel-x86 Architecture*  
**Azalea Raad**, Gil Neiger, John Wickerson, Viktor Vafeiadis  
 Principles of Programming Languages (POPL), 2020  
**Journal Paper**, **Conference Paper** (Rank: A\*)

- [P24] *Weak Persistency Semantics from the Ground Up*  
**Azalea Raad**, John Wickerson, Viktor Vafeiadis  
Object-Oriented Programming, Systems, Languages, and Applications (OOPSLA), 2019  
[Journal Paper](#), [Conference Paper](#) (Rank: A\*)
- [P25] *Effective Lock Handling in Stateless Model Checking*  
Michalis Kokologiannakis, **Azalea Raad**, Viktor Vafeiadis  
Object-Oriented Programming, Systems, Languages, and Applications (OOPSLA), 2019  
[Journal Paper](#), [Conference Paper](#) (Rank: A\*)
- [P26] *Hyperstate Space Graphs for Automated Game Analysis*  
Michael Cook, **Azalea Raad**  
Conference on Games (Cog), 2019  
🏆 **Winner of the best paper award**  
[Conference Paper](#) (Rank: B)
- [P27] *Model Checking for Weakly Consistent Libraries*  
Michalis Kokologiannakis, **Azalea Raad**, Viktor Vafeiadis  
Programming Language Design and Implementation (PLDI), 2019  
[Journal Paper](#), [Conference Paper](#) (Rank: A\*)
- [P28] *On Library Correctness under Weak Memory Consistency*  
**Azalea Raad**, Marko Doko, Lovro Rožić, Ori Lahav, Viktor Vafeiadis  
Principles of Programming Languages (POPL), 2019  
[Journal Paper](#), [Conference Paper](#) (Rank: A\*)
- [P29] *On the Semantics of Snapshot Isolation*  
**Azalea Raad**, Ori Lahav, Viktor Vafeiadis  
Verification, Model Checking and Abstract Interpretation (VMCAI), 2019  
[Conference Paper](#) (Rank: B)
- [P30] *Persistence Semantics for Weak Memory*  
**Azalea Raad**, Viktor Vafeiadis  
Object-Oriented Programming, Systems, Languages, and Applications (OOPSLA), 2018  
[Journal Paper](#), [Conference Paper](#) (Rank: A\*)
- [P31] *On Parallel Snapshot Isolation and Release/Acquire Consistency*  
**Azalea Raad**, Ori Lahav, Viktor Vafeiadis  
European Symposium on Programming (ESOP), 2018  
[Conference Paper](#) (Rank: A)
- [P32] *Inferring Design Constraints from Game Ruleset Analysis*  
Michael Cook, Simon Colton, **Azalea Raad**  
IEEE Conference on Computational Intelligence and Games (CIG), 2018  
[Conference Paper](#) (Rank: B)
- [P33] *Verifying Concurrent Graph Algorithms*  
**Azalea Raad**, Aquinas Hobor, Jules Villard, Philippa Gardner  
Asian Symposium on Programming Languages and Systems (APLAS), 2016  
[Conference Paper](#) (Rank: B)
- [P34] *DOM: Specification and Client Reasoning*  
**Azalea Raad**, José Fragoso Santos, Philippa Gardner  
Asian Symposium on Programming Languages and Systems (APLAS), 2016  
[Conference Paper](#) (Rank: B)

[P35] *CoLoSL: Concurrent Local Subjective Logic*  
**Azalea Raad**, Jules Villard, Philippa Gardner  
European Symposium on Programming (ESOP), 2015  
**Conference Paper** (Rank: A)

[P36] *Abstract Local Reasoning for Concurrent Libraries: Mind the Gap*  
Philippa Gardner, **Azalea Raad\***, Adam Wright, Mark Wheelhouse  
Mathematical Foundations of Programming Semantics (MFPS), 2014  
(\* author list in alphabetical order – Raad and Wright have joint first authorship)  
**Conference Paper** (Rank: B)

[P37] *Mechanic Miner: Reflection-Driven Game Mechanic Discovery And Design*  
Michael Cook, Simon Colton, **Azalea Raad**, Jeremy Gow  
EvoGames Workshop at European Conference on Applications of Evolutionary Computation, 2013  
**Workshop Paper**

[P38] *A Sip of the Chalice*  
**Azalea Raad**, Sophia Drossopoulou  
Functional Techniques for Java-like Programs (FTfJP), 2011  
**Workshop Paper**

[P39] *Ludic Considerations of Tablet-Based Evo-Art*  
Simon Colton, Michael Cook, **Azalea Raad**  
EvoMusArt Workshop at European Conference on Applications of Evolutionary Computation, 2011  
**Workshop Paper**

## KEYNOTE AND INVITED TALKS DURING INDEPENDENT CAREER

[T1] **Invited Talk** **March 2025**  
*Incorrectness Logic & Under-Approximation: Foundations of Bug Detection*  
Program Analysis Seminar, University of Pisa

[T2] **Invited Talk** **November 2024**  
*Strength in Weakness: The Ubiquity of Weak Memory Models*  
Reach Emerging Architectures and Computing Horizons ([Reach](#))

[T3] **Keynote Talk** **September 2024**  
*Bug Detection at Scale*  
International Conference on Concurrency Theory (CONCUR)

[T4] **Keynote Talk** **January 2024**  
*Under-approximation for Scalable Bug Detection*  
ACM SIGPLAN International Conference on Certified Programs and Proofs (CPP)

[T5] **Invited Talk** **June 2024**  
*Bug Detection at Scale*  
Symposium on Games, Automata, Logics, and Formal Verification (GandALF)

[T6] **Invited Talk** **September 2023**  
*Principles of Persistent Programming*  
Trends in Concurrency Theory (TRENDS)

<b>[T7] Invited Talk</b> <i>Under-approximation for Scalable Bug Detection</i> Young Researchers Workshop on Concurrency Theory (YR-CONCUR)	<b>September 2023</b>
<b>[T8] Keynote Talk</b> <i>Principles of Persistent Programming</i> Federated Conference on Distributed Computing Techniques (DisCoTec)	<b>June 2023</b>
<b>[T9] Keynote Talk</b> <i>Incorrectness Logic for Scalable Bug Detection</i> Mathematical Foundations of Programming Semantics (MFPS)	<b>June 2023</b>
<b>[T10] Invited Talk</b> <i>Incorrectness Logic for Scalable Bug Detection</i> Conference on High Confidence Software and Systems conference (HCSS)	<b>May 2023</b>
<b>[T11] Invited Talk</b> <i>Incorrectness Logic for Scalable Bug Detection</i> Iris Workshop	<b>May 2023</b>
<b>[T12] Keynote Tutorial</b> <i>Incorrectness Logic and Under-approximation: Foundations of Bug Catching</i> Principles of Programming Languages (POPL)	<b>January 2023</b>
<b>[T13] Invited Talk</b> <i>Incorrectness Logic for Scalable Bug Detection</i> Workshop on Dependable and Secure Software Systems (DSSS)	<b>October 2022</b>
<b>[T14] Invited Talk</b> <i>Extending Intel-x86 Consistency and Persistency</i> Novel Architecture and Novel Design Automation (NANDA) Workshop	<b>September 2022</b>
<b>[T15] Invited Talk</b> <i>Scalable, Concurrent Bug Catching: Concurrent Incorrectness Separation Logic</i> Testing and Verification Symposium at Facebook, 2021	<b>December 2021</b>
<b>[T16] Keynote Tutorial</b> <i>Beyond Weak Memory Consistency: The Challenges of Memory Persistency</i> Programming Language Design and Implementation (PLDI), 2021	<b>June 2021</b>
<b>[T17] Invited Talk</b> <i>Compositional Bug Catching: Incorrectness Separation Logic</i> World Logic Day	<b>January 2021</b>
<b>[T18] Invited Talk</b> <i>Specifying and Verifying Non-Volatile Memory</i> Verification of Distributed Systems (VDS)	<b>June 2019</b>
<b>[T19] Keynote Talk</b> <i>Correctness in a Weakly Consistent Setting</i> Asian Symposium on Programming Languages and Systems (APLAS)	<b>December 2018</b>
<b>[T20] Invited Talk</b> <i>Verifying Concurrent Graph Algorithms</i> Northern Concurrency Workshop	<b>January 2017</b>

[T21] **Invited Tutorial Talk** **June 2015**  
*CoLoSL: Why Not Frame All the Way?*  
 Mathematical Foundations of Programming Semantics (MFPS)

[T22] **Invited Talk** **May 2015**  
*CoLoSL: Concurrent Local Subjective Logic*  
 Dagstuhl Seminar 15191: *Compositional Verification Methods for Next-Generation Concurrency*

[T23] **Invited Talk** **April 2015**  
*CoLoSL: Concurrent Local Subjective Logic*  
 Theory Seminar at the University of Birmingham

[T24] **Invited Talk** **December 2014**  
*CoLoSL: Compositional Reasoning at Last!*  
 Research Visit at the Max Planck Institute for Software Systems, Saarbrücken, Germany

## RESEARCH GROUP VERITAS

Founder and Leader of [Veritas Lab](#)

### Post-Doctoral Researchers

- Guillaume Ambal October 2022 – Present
- Paulo de Vilhena April 2023 – Present
- Sacha-Élie Ayoun September 2024 – Present
- Matthew Griffin May 2024 – March 2025

### PhD Students

- Shing-Hin Ho January 2023 – Present
- Pedro Carrott October 2023 – Present
- Julien Vanegue (funded by Bloomberg) October 2023 – Present
- Raquel Sofia Silva October 2024 – Present
- Opale Sjöstedt February 2025 – Present

### Visiting Researchers

- Flavio Ascari June 2024 – July 2024

### Master's Students

- Max Stupple October 2024 – Present
- Tiberiu Bucur October 2022 – June 2023  
 **Winner of the Corporate Partnership Prize**
- Ezra Sitorus October 2022 – June 2023
- Aris Zhu October 2022 – June 2023
- Rini Banerjee October 2021 – June 2022  
 **Winner of the ARM project prize for an outstanding project in computer systems**

### Summer Interns

- Caroline Cronjäger 2023, 2024
- Ines Wright 2024



## SELECTED AWARDS AND PRIZES

<b>Distinguished Paper Award</b> Object-Oriented Programming, Systems, Languages, and Applications (OOPSLA)	<b>2022</b>
<b>Distinguished Artifact Award</b> , European Symposium on Programming (ESOP)	<b>2022</b>
<b>Imperial College President’s Award for Excellence in Research</b> (Early Career Researcher)	<b>2021</b>
<b>Best Paper Award</b> , Conference on Games (CoG) <i>Hyperstate Space Graphs for Automated Game Analysis</i>	<b>2019</b>

## PROFESSIONAL SERVICES

### Organisation

1. Organiser of the *Theory and Practice of Static Analysis* workshop at POPL, 2025
2. Organiser of the *VeTSS Annual Meeting*, 2024
3. Organiser of the *VeTSS Summer School*, 2024
4. Organiser of the *Future of Weak Memory* workshop at POPL, 2024
5. Organiser of the *Formal Methods for Incorrectness* workshop at POPL, 2024
6. Organiser of the *O’Hearn Fest* (Festschrift for Prof. Peter O’Hearn) at POPL, 2024
7. Organiser of Dagstuhl seminar on *Formal Methods for Correct Persistent Programming*, 2023
8. Organiser of the *VeTSS Annual Meeting*, 2023
9. Organiser of the *VeTSS Summer School*, 2023
10. Organiser of the *Concurrency Meeting* at the Isaac Newton Institute, 2022
11. Co-chair of the *Student Research Competition at POPL*, 2022
12. Organiser of Dagstuhl seminar 21462 on *Foundations of Persistent Programming*, 2021
13. Co-chair of the *Student Research Competition at POPL*, 2021
14. Organiser of the *Programming Languages Mentoring Workshop (PLMW) at POPL*, 2021
15. Accessibility chair of *Programming Language Design and Implementation (PLDI)*, 2020

### Program Chair

- Conference on Verified Software: Theories, Tools, and Experiments (VSTTE), 2024

### Program Committee Membership

1. European Symposium on Programming (ESOP): 2024
2. Principles of Programming Languages (POPL): 2023, 2020
3. International Conference on Functional Programming (ICFP), 2022
4. Computer-Aided Verification (CAV), 2022

5. Programming Language Design and Implementation (PLDI): 2025, 2021, 2020 (external)
6. Object-Oriented Programming, Systems, Languages, and Applications (OOPSLA): 2025, 2020, 2018 (external member)
7. Verification, Model Checking, and Abstract Interpretation (VMCAI), 2021
8. International Conference on Networked Systems (NETYS), 2020
9. European Conference on Object-Oriented Programming (ECOOP), 2019
10. Mathematical Foundations of Programming Semantics (MFPS), 2018
11. Syntax and Semantics of Low-Level Languages (LOLA), 2018
12. European Symposium on Programming (ESOP), 2017 (external reviewer)
13. International Workshop on Aliasing, Capabilities and Ownership (IWACO), 2017
14. Student Research Competition at POPL, 2020
15. Student Research Competition at PLDI, 2019
16. Student Research Competition at ICFP, 2019
17. Student Research Competition Judge at the Asian Symposium on Programming Languages and Systems (APLAS), 2018

### PhD Examinations

1. Frank Busse, Imperial College London, 2025
2. Miguel Matos, University of Lisbon, 2024
3. Simon Friis Vindum, Aarhus University, 2023
4. Daniel Wright, University of Kent, 2023

### Journal Reviews

- Journal of the American Computer Machinery, 2022
- Foundations and Trends in Programming Languages, 2020

## TEACHING

<b>The Theory and Practice of Concurrent Programming</b>	<b>2021–Present</b>
Third year course (Imperial College London); co-designed the course	
<b>Models of Computation</b>	<b>2020; 2021</b>
Second year course (Imperial College London)	
<b>Logic and Reasoning</b>	<b>2020</b>
First year course (Imperial College London)	