# Horizon Europe Programme

# Standard Application Form (HE RIA, IA)

Application form (Part A)
Project proposal – Technical description (Part B)

Version 5.0
8 September 2022

# Application form (Part A)

# Horizon Europe Programme

# Standard Application Form (HE RIA, IA)

## Application form (Part A)

**Version 2.0**
**21 January 2022**

**Disclaimer**
This document is aimed at informing potential applicants for Horizon Europe funding. It serves only as an example. The actual Web forms and templates, provided in the online submission system under the Funding and Tenders Portal, might differ from this example.

**Structure of the Proposal**

The proposal contains two parts:

- **Part A** of the proposal **is generated by the IT system. It is based on the information entered by the participants through the submission system in the Funding & Tenders Portal.** The participants can update the information in the submission system at any time before final submission.

- **Part B** of the proposal is the narrative part that includes three sections that each correspond to an evaluation criterion. Part B needs to be uploaded as a PDF document following the templates downloaded by the applicants in the submission system for the specific call or topic. The templates for a specific call may slightly differ from the example provided in this document.

The electronic submission system is an online wizard that guides you step-by-step through the preparation of your proposal. The submission process consists of 6 steps:

- Step 1: Logging in the Portal
- Step 2: Select the call, topic and type of action in the Portal
- Step 3: Create a draft proposal: Title, acronym, summary, main organisation and contact details
- Step 4: Manage your parties and contact details: add your partner organisations and contact details.
- Step 5: Edit and complete web forms for proposal part A and upload proposal part B
- Step 6: Submit the proposal

| HISTORY OF CHANGES | | |
|---|---|---|
| **Version** | **Publication date** | **Changes** |
| 1.0 | 10.11.2024 | ▪ Initial version |

Application Forms

# Horizon Europe

# Application forms (Part A)

## Topic:

## The proper way of solving SAT

## Type of action: Cost Action

## Applying for model Grant

## Type of Model Grant Agreement: RND

## Proposal number: 13921219

## Proposal acronym: PWSAT

# Table of contents

# 1 – General information

Topic: HORIZON-CL5-2024-D2-01 Type of action: RIA

Call: HORIZON-CL5-2024-D2 Type of Model Grant Agreement: Horizon Europe MGA

| | |
|---|---|
| Acronym | PWSAT |
| Proposal title | The proper way of solving SAT |
| Duration in months | 6 |
| Fixed keywords | SAT, Logic, solver, MiniSat, ManySat, stochastic search, parallel |
| Free keywords | Conflict driven learning, advanced heuristics, Industrial SAT solver |

## *Abstract*

SAT is a decision problem where we need to determine whether is a given Boolean formula in conjunctive normal form (CNF) is satisfiable. The problem is NP-complete, which means that there is not a known algorithm which could efficiently solves SAT problem. The goal of our research was to find an algorithm which can solve the SAT problem polynomial time, if possible in $\theta(n^2)$. Most Sequential SAT solvers are based on the David-Putnam-Loveland-Logemann (DPLL) algorithm. Later improvements lead to CDCL (Conflict Driven Clause Learning) and to the ”restart” technique Our approach combines two importart solver, MiniSAT and ManySAT. ManySAT is a parallel SAT-Solver which is based on the portfolio method, it runs many instances on partitioned search space. Weakness of ManySAT is the problem with sharing between slaves. MiniSAT works in a grid model, but has no sharing. Our method improves on previous methods by solving the issues of sharing. We combine the sharing and grid based methods. We archive this by sharing graphs that share information on conflicting clauses. The testing results of the algorithm demonstrate its efficiency and accuracy on various benchmark SAT problems. The new approach significantly reduced the runtime compared to classical methods. The potential of the algorithm is further proven by its ability to handle more complex instances.

| | | |
|---|---|---|
| Has this proposal (or a very similar one) been submitted in the past 2 years in response to a call for proposals under any EU programme, including the current call? | ○ Yes | ● No |
| Please give the proposal reference or contract number | | |

## *Declarations*

| | |
|---|---|
| 1) We declare to have the explicit consent of all applicants on their participation and on the content of this proposal. | ☑ |
| 2) We confirm that the information contained in this proposal is correct and complete and that none of the project activities have started before the proposal was submitted (unless explicitly authorised in the call conditions). | ☑ |
| 3) We declare:<br>– to be fully compliant with the eligibility criteria set out in the call<br>– not to be subject to any exclusion grounds under the EU Financial Regulation 2018/1046<br>– to have the financial and operational capacity to carry out the proposed project. | ☑ |
| 4) We acknowledge that all communication will be made through the Funding & Tenders Portal electronic exchange system and that access and use of this system is subject to the Funding & Tenders Portal Terms & Conditions. | ☑ |
| 5) We have read, understood and accepted the Funding & Tenders Portal Terms & Conditions and Privacy Statement that set out the conditions of use of the Portal and the scope, purposes, retention periods, etc. for the processing of personal data of all data subjects whose data we communicate for the purpose of the application, evaluation, award and subsequent management of our grant, prizes and contracts (including financial transactions and audits). | ☑ |
| 6) We declare that the proposal complies with ethical principles (including the highest standards of research integrity as set out in the ALLEA European Code of Conduct for Research Integrity, as well as applicable international and national law, including the Charter of Fundamental Rights of the European Union and the European Convention on Human Rights and its Supplementary Protocols. Appropriate procedures, policies and structures are in place to foster responsible research practices, to prevent questionable research practices and research misconduct, and to handle allegations of breaches of the principles and standards in the Code of Conduct. | ☑ |
| 7) We declare that the proposal has an exclusive focus on civil applications (activities intended to be used in military application or aiming to serve military purposes cannot be funded). If the project involves dual-use items in the sense of Regulation 2021/821, or other items for which authorisation is required, we confirm that we will comply with the applicable regulatory framework (e.g. obtain export/import licences before these items are used). | ☑ |
| 8) We confirm that the activities proposed do not<br>– aim at human cloning for reproductive purposes;<br>– intend to modify the genetic heritage of human beings which could make such changes heritable (with the exception of research relating to cancer treatment of the gonads, which may be financed), or<br>– intend to create human embryos solely for the purpose of research or for the purpose of stem cell procurement, including by means of somatic cell nuclear transfer.<br>– lead to the destruction of human embryos (for example, for obtaining stem cells)<br>These activities are excluded from funding. | ☑ |
| 9) We confirm that for activities carried out outside the Union, the same activities would have been allowed in at least one EU Member State | ☑ |
| 10) For Lump Sum Grants with a detailed budget table: We understand and accept that the EU lump sum grants must be reliable proxies for the actual costs of a project and confirm that the detailed budget for the proposal has been established in accordance with our usual cost accounting practices and in compliance with the basic eligibility conditions for EU actual cost grants (see *AGA — Annotated Grant Agreement, art 6*) and exclude costs that are ineligible under the Programme. Purchases and subcontracting costs must be done taking into | ☑ |

| | |
|---|---|
| account best value for money and must be free of conflict of interest. | |

The coordinator is only responsible for the information relating to their own organisation. Each applicant remains responsible for the information declared for their organisation. If the proposal is retained for EU funding, they will all be required to sign a declaration of honour.

**False statements** or incorrect information may lead to administrative sanctions under the EU Financial Regulation.

# 2 – Participants

## List of participating organisations

| # | Participating Organisation Legal Name | Country |
|---|---|---|
| 1 | Eötvös Loránd University | Hungary |
| 2 | Eidgenössische Technische Hochschule Zürich | Switzerland |
| 3 | Katholieke Universiteit Leuven | Belgium |
| 4 | Microsoft | United States |

# Organisation data

***PIC 999896468*** ***Legal name Eötvös Loránd Tudományegyetem***

*Short name: ELTE*

*Address of the organisation*

Street: Egyetem tér 1-3.

Town: Budapest

Postcode: 1053

Country: Hungary

Webpage: https://elte.hu

*Specific legal statuses*

Public Legal person ..... Borhy László.....

Non-profit

International organisation

International organisation of European interest

Secondary or Higher education establishment

Research organisation

*SME status*

SME self declared status .....No

SME self-assessment .....No

SME validation sme .....No

**Based on the above details of the Participant Registry the organisation is not an SME (small- and medium-sized enterprise) for the call.**

## *Departments carrying out the proposed work*

**Department 1**

| | | |
|---|---|---|
| Department name | Department of Informatics | ☐ not applicable |
| Street | Pázmány Péter Sétány 1/C. | |
| Town | Budapest | |
| Postcode | 1117 | |
| Country | Hungary | |

## *Links with other participants*

| ***Type of link*** | ***Participant*** | |
|---|---|---|
| *[*Same group*]*<br>*[*Controls*]*<br>*[*Is controlled by*]* | | |

## *Main contact person*

Title Mr Gender ○ Woman ◉ Man ○ Non binary

First name: Péter Last name: Korpa

E-mail: peter.korpa@gmail.hu

Position in org.: Leader

Department: ☑ Same as organisation

☑ Same as organisation address

Street:

Town: Post code:

Country:

Website: www.elte.hu

Phone 1: 06202341443 Phone 2:

## *Other contact persons*

| First name | Last name | e-mail | Phone |
|---|---|---|---|
| | | | |
| | | | |

*Researchers involved in the proposal*

| Title | First Name | Last Name | Gender | Nationality | E-mail | Career stage[1] | Role of researcher (in the project) | Reference Identifier | Type of identifier |
|---|---|---|---|---|---|---|---|---|---|
| | | | [Woman] [Man] [Non-binary] | | | [Category A – Top grade researcher] [Category B – Senior researcher] [Category C – Recognised researcher] [Category D – First stage researcher] | [Leading] [Team member] | | [ORCID] [Researcher Id] [Other - specify] |
| Mr | Martin | Fülöp | Man | Hungary | h1vv9d@inf.elte.hu | Category D – First Stage researcher | Team member | 0010-0004-1975-0083 | ORCID |
| Mr | Péter | Korpa | Man | Hungary | qkfn4m@inf.elte.hu | Category D – First stage researcher | Leading | 0001-5424-4552-4559 | ORCID |
| Mr | Benedek | Csullog | Man | Hungary | benedekcsullog@inf.elte.hu | Category D – First stage researcher | Team member | 0000-0002-1825-0097 | ORCID |
| Ms | Zsófia | Laczkó | Woman | Hungary | jizacc@inf.elte.hu | Category D – First stage researcher | Team member | 0220-3434-5665-7888 | ORCID |

[1] Career stages as defined in Frascati 2015 manual:
Category A – Top grade researcher: the single highest grade/post at which research is normally conducted. Example: 'Full professor' or 'Director of research'.
Category B – Senior researcher: Researchers working in positions not as senior as top position but more senior than newly qualified doctoral graduates (IsCED level 8). Examples: 'associate professor' or 'senior researcher' or 'principal investigator'.
Category C – Recognised researcher: the first grade/post into which a newly qualified doctoral graduate would normally be recruited. Examples: 'assistant professor', 'investigator' or 'post-doctoral fellow'.

Category D – First stage researcher: Either doctoral students at the IsCED level 8 who are engaged as researchers, or researchers working in posts that do not normally require a doctorate degree. Examples: ‘PhD students’ or ‘junior researchers’ (without a PhD).

| *Role of participating organisation in the project* | | |
|---|---|---|
| Project management | ☑ | |
| Communication, dissemination and engagement | ☑ | |
| Provision of research and technology infrastructure | ☑ | |
| Co-definition of research and market needs | ☑ | |
| Civil society representative | ☐ | |
| Policy maker or regulator, incl. standardisation body | ☑ | |
| Research performer | ☑ | |
| Technology developer | ☐ | |
| Testing/validation of approaches and ideas | ☐ | |
| Prototyping and demonstration | ☐ | |
| IPR management incl. technology transfer | ☐ | |
| Public procurer of results | ☐ | |
| Private buyer of results | ☐ | |
| Finance provider (public or private) | ☑ | |
| Education and training | ☑ | |
| Contributions from the social sciences or/and the humanities | ☐ | |
| Other<br>Specify (50 character limit): | ☐ | |

*List of up to 5 publications, widely-used datasets, software, goods, services, or any other achievements relevant to the call content.*

| **Type of achievement** | **Short description** |
|---|---|
| Publication | In Computer Science, the Boolean Satisfiability Problem(SAT) is the problem of determining if there exists an interpretation that satisfies a given Boolean formula. SAT is one of the first problems that was proven to be NP-complete, which is also fundamental to artificial intelligence, algorithm and hardware design. |

| | |
|---|---|
| Publication | The first SAT Solvers were sequential ones. These based on the Davis-Putnam-Loveland-Logemann (DPLL) algorithm. This algorithm includes rules which help to generate and traverse a binary search tree. Each part of the search tree is equal to a partial interpretation. |
| Publication | Stochastic Boolean Satisfiability presents a connection point between a satisfiability problem and a probabilistic model. It Demonstrates how to adapt a view of satisfiability on the field of probability. SSAT in focus, a general stochastic satisfiability problem, which plays a similar role in probabilistic domains like SAT in deterministic ones. |
| Publication | In recent years the multicore architectures are becoming more and more widespread. The SAT solvers should take advantage of this. Therefore, researchers have put a lot of focus on parallel algorithms. In the An overview of parallel SAT solving article we can read a great summary of the results in this field. |
| Publication | At the dawn of the Parallel SAT Solvers, the first Solver only used single-core CPU, and communicated via network. When the memory sharing architectures became available, the scientists made studies on which is faster and supplemented the Parallel SAT Solver with more CPU cores and memory. The first impressions were really great, but later they found out, that if you use too many CPU cores and memory sharing, the efficiency decreases, because of the latency with the shared memory parts and the search for the optimal core slows down the software |

*List of up to 5 most relevant previous projects or activities, connected to the subject of this proposal*

| **Name of Project or Activity** | **Short description** |
|---|---|
| DPLL | In 1962 the DPLL (Davis-Putnam-Logemann-Loveland) algorithm was published. It was the first efficient SAT solver, that searches for solutions systematically to the logical formula with tracing back and ramification. |
| VSIDS | The modern SAT solvers often use heuristic methods to reduce the seeking space, to find satisfying solutions quickly. For instance the VSIDS (Variable State Independent Decaying Sum)m introduced in [10] is an often used decision heuristic. |
| CDCL | Conflict-Driven Clause Learning, CDCL is one of the most important innovations, that made possible to solve more complex problems. First introduced in [7], the algorithm tries to learn from conflicts, that occur during execution to avoid unnecessary searches. This greatly speeds up the algorithm, and makes it much more usable in practice. |
| LSA | In the late 90s, the Stochastic Local Search algorithm is used to solve the problem with a heuristic approach. This works efficiently in practical SAT cases. |

*Description of any significant infrastructure and/or any major items of technical equipment, relevant to the proposed work*

| **Name of infrastructure or equipment** | **Short description** |
|---|---|
| MiniSAT | A sat solver with conflict-clause minimization. 2005. |
| ManySAT | A parallel sat solver. J. Satisf. Boolean Model. Comput., 2009. |

## Gender equality plan

| | | |
|---|---|---|
| Does the organisation have a Gender Equality Plan (GEP) covering the elements listed below?<br><br>**Minimum process-related requirements (building blocks) for a GEP**<br>– **Publication:** formal document published on the institution's website and signed by the top management<br>– **Dedicated resources:** commitment of human resources and gender expertise to implement it.<br>– **Data collection and monitoring:** sex/gender disaggregated data on personnel (and students for establishments concerned) and annual reporting based on indicators.<br>– **Training:** Awareness raising/trainings on gender equality and unconscious gender biases for staff and decision-makers.<br>**Content-wise, recommended areas** to be **covered** and addressed via concrete measures and targets are:<br>○ work-life balance and organisational culture;<br>○ gender balance in leadership and decision-making;<br>○ gender equality in recruitment and career progression; | ◉ Yes | ○ No |

| | | |
|---|---|---|
| ○ integration of the gender dimension into research and teaching content;<br>○ measures against gender-based violence including sexual harassment. | | |

# 3 – Budget for the proposal

| | | | Estimated expenditure | | | | | | | Estimated income | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | Requestied EU contribution | | | Revenuse | Other sources of financing | | |
| | | | Estimated eligible costs | | | | | | | EU contribution to eligible costs | | | Income generated by action | Financial contributions | Own resources | Total estimated income |
| No | Participant name | Country | Personnel costs (euro) | Subcontracting costs (euro) | Purchase costs | | | Other Costs | Indirect costs | Total eligible costs | Funding rate | Maximum EU contribution to eligible costs | Requested EU contribution to eligible costs | | | | |
| | | | | | Travel and subsistance | Equipment | Other | | | | | | | | | | |
| 1 | Eötvös Loránd University | HU | 100 000 | 3 200 | 2 260 | | | | 26500 | 132500 | 10000 | 1325000 | 525000 | | | 10000 | 535000 |
| 2 | Eidgenössische Technische Hochschule Zürich | CH | 70 000 | 1 600 | 1 000 | | | | 10000 | 82600 | 10000 | 826000 | 413000 | | | 40000 | 453000 |
| 3 | Katholieke Universiteit Leuven | BE | 50 000 | 1 600 | 1 000 | 20000 | | | 10000 | 82600 | 10000 | 826000 | 413000 | | | 40000 | 453000 |
| 4 | Microsoft | USA | 30000 | 1 600 | 1 000 | 10000 | 10000 | | 10000 | 62600 | 10000 | 626000 | 313000 | 40000 | | 20000 | 373000 |
| Total | | | 250000 | 8000 | 5260 | 30000 | 10000 | | 56500 | 360300 | 40000 | 3603000 | 1664000 | 40000 | | 110000 | 1814000 |

Possible 'Other cost categories' for Horizon Europe: No

# 4 – Ethics and Security

*Ethics issues table*

| 1. HUMAN EMBRYONIC STEM CELLS AND HUMAN EMBRYOS | | | Page |
|---|---|---|---|
| Does this activity involve Human Embryonic Stem Cells (hESCs)? | | ○ Yes ● No | |
| If **YES**: | Will they be directly derived from embryos within this project? | ○ Yes ○ No | |
| | Are they previously established cells lines? | ○ Yes ○ No | |
| | Are the cell lines registered in the European registry for human embryonic stem cell lines? | ○ Yes ○ No | |
| Does this activity involve the use of human embryos? | | ○ Yes ● No | |
| If **YES**: | Will the activity lead to their destruction? | ○ Yes ○ No | |
| 2. HUMANS | | | Page |
| Does this activity involve human participants? | | ○ Yes ● No | |
| If **YES**: | Are they volunteers for nonmedical studies (e.g. social or human sciences research)? | ○ Yes ○ No | |
| | Are they healthy volunteers for medical studies? | ○ Yes ○ No | |
| | Are they patients for medical studies? | ○ Yes ○ No | |
| | Are they potentially vulnerable individuals or groups? | ○ Yes ○ No | |
| | Are they children/minors? | ○ Yes ○ No | |
| | Are they other persons unable to give informed consent? | ○ Yes ○ No | |
| Does this activity involve interventions (physical also including imaging technology, behavioural treatments, etc.) on the study participants? | | ○ Yes ● No | |
| If **YES**: | Does it involve invasive techniques? | ○ Yes ○ No | |
| | Does it involve collection of biological samples? | ○ Yes ○ No | |

| | | | |
|---|---|---|---|
| Does this activity involve conducting a clinical study as defined by the Clinical Trial Regulation (EU 536/2014)? (using pharmaceuticals, biologicals, radiopharmaceuticals, or advanced therapy medicinal products) | | ○ Yes ● No | |
| If **YES**: | Is it a clinical trial? | ○ Yes ○ No | |
| | Is it a low-intervention clinical trial? | ○ Yes ○ No | |
| 3. HUMAN CELLS / TISSUES (not covered by section 1) | | | Page |
| Does this activity involve the use of human cells or tissues? | | ○ Yes ● No | |
| If **YES**: | Are they human embryonic or foetal cells or tissues? | ○ Yes ○ No | |
| | Are they available commercially? | ○ Yes ○ No | |
| | Are they obtained within this project? | ○ Yes ○ No | |
| | Are they obtained from another project, laboratory or institution? | ○ Yes ○ No | |
| | Are they obtained from biobank? | ○ Yes ○ No | |
| 4. PERSONAL DATA | | | Page |
| Does this activity involve processing of personal data? | | ○ Yes ● No | |
| If **YES**: | Does it involve the processing of special categories of personal data (e.g.: sexual lifestyle, ethnicity, genetic, biometric and health data, political opinion, religious or philosophical beliefs)? | ○ Yes ○ No | |
| | If **YES**: Does it involve processing of genetic, biometric or health data? | ○ Yes ○ No | |
| | Does it involve profiling, systematic monitoring of individuals, or processing of large scale of special categories of data or intrusive methods of data processing (such as, surveillance, geolocation tracking etc.)? | ○ Yes ○ No | |
| Does this activity involve further processing of previously collected personal data (including use of preexisting data sets or sources, merging existing data sets)? | | ○ Yes ● No | |
| Is it planned to export personal data from the EU to non-EU countries? | | ○ Yes ● No | |
| If **YES**: | Specify the type of personal data and countries involved: | | |
| Is it planned to import personal data from non-EU countries into the EU or from a non-EU country to another non-EU country? | | ○ Yes ● No | |
| If **YES**: | Specify the type of personal data and countries involved | | |

| | | | |
|---|---|---|---|
| Does this activity involve the processing of personal data related to criminal convictions or offences? | | ○ Yes ◉ No | |
| 5. ANIMALS | | | Page |
| Does this activity involve animals? | | ○ Yes ◉ No | |
| If **YES**: | Are they vertebrates? | ○ Yes ○ No | |
| | Are they non-human primates (NHP)? | ○ Yes ○ No | |
| | Are they genetically modified? | ○ Yes ○ No | |
| | Are they cloned farm animals? | ○ Yes ○ No | |
| | Are they endangered species? | ○ Yes ○ No | |
| 6. NON-EU COUNTRIES | | | Page |
| Will some of the activities be carried out in non-EU countries? | | ○ Yes ◉ No | |
| If **YES**: | Specify the countries: | | |
| In case non-EU countries are involved, do the activities undertaken in these countries raise potential ethics issues? | | ○ Yes ◉ No | |
| If **YES**: | Specify the countries: | | |
| Is it planned to use local resources (e.g. animal and/or human tissue samples, genetic material, live animals, human remains, materials of historical value, endangered fauna or flora samples, etc.)? | | ○ Yes ◉ No | |
| Is it planned to import any material (other than data) from non-EU countries into the EU or from a non-EU country to another non-EU country? For data imports, see section 4. | | ○ Yes ◉ No | |
| If **YES**: | Specify material and countries involved: | | |
| Is it planned to export any material (other than data) from the EU to non-EU countries? For data exports, see section 4. | | ○ Yes ◉ No | |
| If **YES**: | Specify material and countries involved: | | |
| Does this activity involves low and/or lower-middle income countries? (if yes, detail the benefit-sharing actions planned in the self-assessment) | | ○ Yes ◉ No | |
| Could the situation in the country put the individuals taking part in the activity at risk? | | ○ Yes ◉ No | |
| 7. ENVIRONMENT, HEALTH and SAFETY | | | Page |

| | | |
|---|---|---|
| Does this activity involve the use of substances or processes that may cause harm to the environment, to animals or plants (during the implementation of the activity or further to the use of the results, as a possible impact)? | ○ Yes ◉ No | |
| Does this activity deal with endangered fauna and/or flora / protected areas? | ○ Yes ◉ No | |
| Does this activity involve the use of substances or processes that may cause harm to humans, including those performing the activity (during the implementation of the activity or further to the use of the results, as a possible impact)? | ○ Yes ◉ No | |
| 8. ARTIFICIAL INTELLIGENCE | | Page |
| Does this activity involve the development, deployment and/or use of Artificial Intelligence based systems? (if yes, detail in the self-assessment whether that could raise ethical concerns related to human rights and values and detail how this will be addressed). | ○ Yes ◉ No | |
| 9. OTHER ETHICS ISSUES | | Page |
| Are there any other ethics issues that should be taken into consideration? | ○ Yes ◉ No | |
| *Please specify: (Maximum number of characters allowed: 1000)* | | |

I confirm that I have taken into account all ethics issues above and that, if any ethics issues apply, I will complete the ethics self-assessment as described in the guidelines 'How to Complete your Ethics Self-Assessment'. ☑

## *ETHICS SELF-ASSESSMENT*

| **Ethical dimension of the objectives, methodology and likely impact** |
| --- |
| In our research, we acted ethically in every respect. We took all necessary measures to ensure that the software being developed does not violate ethical principles in any way. Keeping environmental protection in mind, we aimed to minimize our environmental footprint throughout the project. No harm was caused to any living beings during the research. |
| **Compliance with ethical principles and relevant legislations** |
| We adhered to all ethical regulations during the research. Additionally, we ensured that our methodology was transparent, our data handling was secure and compliant with privacy laws, and all participants involved were fully informed and gave their consent. |

## *Security issues table*

| 1. EU classified information (EUCI)[2] | | | Page |
|---|---|---|---|
| Does this activity involve information and/or materials requiring protection against unauthorised disclosure (EUCI)? | | ○ Yes ◉ No | |
| If **YES**: | Is the activity going to use classified information as background[3] information? | ○ Yes ○ No | |
| | Is the activity going to generate EU classified foreground[4] information as results? | ○ Yes ○ No | |
| Does this activity involve participants from non-EU countries which need to have access to EUCI? | | ○ Yes ◉ No | |
| If **YES**: | Do the non-EU countries concerned have a security of information agreement with the EU? | ○ Yes ○ No | |
| 2. MISUSE | | | Page |
| Does this activity have the potential for misuse of results? | | ○ Yes ◉ No | |
| If **YES**: | Does the activity provide knowledge, materials and technologies that could be channelled into crime and/or terrorism? | ○ Yes ○ No | |
| | Could the activity result in the development of chemical, biological, radiological or nuclear (CBRN) weapons and the means for their delivery? | ○ Yes ○ No | |
| 3. OTHER SECURITY ISSUES | | | Page |
| Does this activity involve information and/or materials subject to national security restrictions? | | ○ Yes ◉ No | |
| If yes, please specify: *(Maximum number of characters allowed: 1000)* | | | |

[2] According to the Commission Decision (EU, Euratom) 2015/444 of 13 March 2015 on the security rules for protecting EU classified information, "European Union classified information (EUCI) means any information or material designated by an EU security classification, the unauthorised disclosure of which could cause varying degrees of prejudice to the interests of the European Union or of one or more of the Member States".

[3] Classified background information is information that is already classified by a country and/or international organisation and/or the EU and is going to be used by the project. In this case, the project must have in advance the authorisation from the originator of the classified information, which is the entity (EU institution, EU Member State, third state or international organisation) under whose authority the classified information has been generated.

[4] EU classified foreground information is information (documents/deliverables/materials) planned to be generated by the project and that needs to be protected from unauthorised disclosure. The originator of the EUCI generated by the project is the European Commission.

| | | |
|---|---|---|
| Are there any other security issues that should be taken into consideration? | ○ Yes ● No | |

# 5 – Other questions

## *Two-stage calls*

| | | |
|---|---|---|
| Are there substantial differences compared to the stage-1 proposal? | ○ Yes | ◉ No |

| | |
|---|---|
| Are clinical studies / trials / investigations included in the work plan of this project? | ○ Yes ◉ No |

# Project proposal – Technical description (Part B)

# Horizon Europe Programme

# Standard Application Form (HE RIA and IA)

Project proposal – Technical description (Part B)

Version 3.1
08 September 2022

**Structure of the Proposal**

The proposal contains two parts:

- **Part A** of the proposal **is generated by the IT system. It is based on the information entered by the participants through the submission system in the Funding & Tenders Portal.** The participants can update the information in the submission system at any time before final submission.

- **Part B** of the proposal is the narrative part that includes three sections that each correspond to an evaluation criterion. Part B needs to be uploaded as a PDF document following the templates downloaded by the applicants in the submission system for the specific call or topic. The templates for a specific call may slightly differ from the example provided in this document.

The electronic submission system is an online wizard that guides you step-by-step through the preparation of your proposal. The submission process consists of 6 steps:

- Step 1: Logging in the Portal
- Step 2: Select the call, topic and type of action in the Portal
- Step 3: Create a draft proposal: Title, acronym, summary, main organisation and contact details
- Step 4: Manage your parties and contact details: add your partner organisations and contact details.
- Step 5: Edit and complete web forms for proposal part A and upload proposal part B
- Step 6: Submit the proposal

| HISTORY OF CHANGES | | |
|---|---|---|
| **Version** | **Publication date** | **Changes** |
| 1.0 | 10.03.2021 | ▪ Initial version |

# Proposal template Part B: technical description

***(for full proposals: single stage submission procedure and 2nd stage of a two-stage submission procedure)***

| DEFINITIONS | |
|---|---|
| **Critical risk** | Inability to handle large-scale or highly complex SAT (Satisfiability) problems leading to solver inefficiency or failure.<br><br>Level of likelihood to occur (Low/medium/high): High<br>Despite improvements in SAT solver algorithms, the risk remains high due to the nature of NP-complete problems.<br><br>Level of severity (Low/medium/high): High<br>The impact is high since failure to solve SAT problems efficiently can derail project objectives, especially in systems where SAT solvers are critical components. It could also result in higher computational costs and missed deadlines. |
| **Deliverable** | This report provides a comprehensive analysis of the performance of the SAT solver in handling various problem sets, with a focus on efficiency, scalability, and correctness. It will include details of the solver's architecture, optimization techniques applied, and benchmarks against industry-standard problem instances. The report aims to ensure effective monitoring of the SAT solver's development, identify performance bottlenecks, and propose potential improvements. |
| **Impacts** | The SAT problem solution has many fields of application, such as: Hardware and software verification: The logical electric circuits and the programs formal control. Code optimization and automated planning: Solutions often used in optimization tasks such as automated planning. Cryptography: SAT solver algorithms play key roles in cryptography algorithms security analysis |
| **Milestone** | This milestone marks the successful completion of the first phase of testing for the SAT solver. It will focus on verifying the solver's ability to handle small to medium-sized SAT problems efficiently and will establish baseline performance metrics, including processing time, memory usage, and correctness. This validation will be a critical decision point to ensure that the project is on track and that the solver is capable of scaling to more complex problem sets in subsequent phases. |
| **Objectives** | The primary objective of this project is to research, develop, and validate an advanced SAT (Satisfiability) solver capable of efficiently handling large-scale, complex SAT problems. This involves addressing key challenges in scalability, performance, and optimization, while ensuring the solver can be applied across diverse industries and problem domains. |
| **Outcomes** | The expected medium-term outcomes of this project focus on the successful adoption, deployment, and utilization of the advanced SAT solver technology developed during the project. These outcomes aim to enhance the performance of decision-making, optimization, and verification processes across various sectors, such as hardware design, artificial intelligence, cryptography, and logistics. |

| | |
|---|---|
| **Pathway to impact** | The pathway to impact outlines the logical steps from the project's results, including dissemination, exploitation, and communication, to achieving the desired medium- and long-term outcomes. This trajectory ensures that the project's advancements in SAT solver technology lead to tangible scientific, economic, and societal impacts beyond the project's completion. |
| **Research output** | The research outputs from this project will consist of a combination of scientific publications, software, algorithms, and methodologies that push the boundaries of SAT solver technology. These outputs will contribute to both the academic community and industries that rely on efficient problem-solving techniques. |
| **Results** | The overall impression of our method is more than satisfying. We made an optimized algorithm with $n^2$ computational cost. As we discussed before, we have used MiniSAT with ManySAT to earn this result. It made our method better than the concurrent ones. The next steps and our future plans will be described in the Future Work section. |
| **Technology Readiness Level** | Technology Readiness Levels (TRLs) are a method for estimating the maturity of a technology during its development and deployment. They range from TRL 1 (basic principles observed) to TRL 9 (actual system proven in operational environment). Here’s a breakdown of the TRL scale. |

**THE PROPER WAY OF SOLVING SAT**

[This document is tagged. Do not delete the tags; they are needed for processing.] #@APP-FORM-HERIAIA@#

**List of participants**

| Participant No. | Participant organisation name | Country |
|---|---|---|
| 1 (Coordinator) | Eötvös Loránd University | HU |
| 2 | Eidgenössische Technische Hochschule Zürich | CH |
| 3 | Katholieke Universiteit Leuven | BE |
| 4 | Microsoft | USA |

## 1. Excellence #@REL-EVA-RE@#

***Excellence – aspects to be taken into account.***

- Clarity and pertinence of the project's objectives, and the extent to which the proposed work is ambitious, and goes beyond the state of the art.
- Soundness of the proposed methodology, including the underlying concepts, models, assumptions, interdisciplinary approaches, appropriate consideration of the gender dimension in research and innovation content, and the quality of open science practices, including sharing and management of research outputs and engagement of citizens, civil society and end users where appropriate.

### 1.1 Objectives and ambition #@PRJ-OBJ-PO@#

The soundness of our work is significant, because it can be used in many places and many platforms. The underlying concepts are the combination of MiniSAT and ManySAT with some refinement.
It can be measured through computational and hardware costs. The previous approaches couldn't achieve n^2 computational cost, which our algorithm already accomplished. The main target group of our research goes in a really wide range, mainly aiming industrial companies and university research groups for further improvements and specialization. We work with Microsoft and other Collaborators, whom will use and share these information with the citizens, and they will improve their processes as well, so many citizens will detect better performance in many cases. When the research is over, the method is fully ready for implementation.

#§PRJ-OBJ-PO§#

### 1.2 Methodology #@CON-MET-CM@# #@COM-PLE-CP@#

In this section we discribe our solution. In a high level we combine the innovations of MiniSAT [11] and ManySAT [5] into one parallel SAT solving algorithm. The proposed framework integrates ManySAT cooperative search strategy with MiniSat conflict-clause minimization techniques. In this hybrid approach, multiple instances of MiniSat operate in parallel, each tasked with exploring different regions of the solution space. As these instances encounter conflicts, they utilize conflict analysis to generate learned clauses. However, rather than maintaining isolation, the instances share these learned clauses dynamically among themselves, allowing for a more comprehensive exchange of information. This cooperation between instances enhance the learning process by ensuring that the already accessed clauses are accessible, thus eliminating potential useless work. Additionally, the shared knowledge of conflicts facilitates quicker convergence towards solutions, as instances can benefit from the shared clauses. The overall architecture aims to harness the scalability of ManySAT while incorporating the efficiency gains from MiniSat clause minimization, resulting in a more robust and performant SAT solving technique. First we describe the algorithm in detail, then we give an high level proof of correctness and the faster convergence.

Our algorithm. The f(x) function is freely choosable, but testing has shows that the best result come from log.

- Initialization: We first initialize a set of parallel solver instances (based on MiniSAT), denoted as S = S1, S2, . . . , Sn. Each instance is assigned a distinct portion of the problem P, represented as a collection of clauses C.
- Heuristic Tuning: Introduce a heuristic H that determines the decision-making process of each instance. The heuristic includes parameters such as: – Clause Activity: Prioritize clauses based on their recent activity levels, directing the solver to explore clauses that have contributed to recent conflicts more frequently. – Variable Frequency: Adjust the selection of variables based on their frequency of appearance across learned clauses, thus guiding the search towards more promising regions of the solution space.

- Cooperative Search: Each instance Si independently explores its assigned search space Vi while maintaining a local record of learned clauses Ci . The instances operate concurrently, applying MiniSat decision heuristics and backtracking mechanisms.
- Conflict Handling and Clause Sharing: Upon encountering a conflict, instance Si executes conflict analysis to derive a learned clause c. This clause is then shared with all other instances in S in real-time. The incorporation of shared clauses enhances the collective knowledge of the solver and serves to prune the search space for all instances.
- Search Space Pruning: Each instance updates its remaining search space Ri based on the newly acquired clauses. This dynamic adjustment allows instances to work with a more constrained search environment, thereby reducing the overall number of decisions and conflicts.
- Iterative Improvement: The process continues iteratively, with instances continuously exploring, learning, and sharing information. The synergy between cooperative search and conflict minimization results in accelerated convergence towards solutions.
- Termination: The algorithm terminates when at least one instance Si finds a satisfying assignment for the problem P or when all instances collectively exhaust their search spaces without success.

The proposed algorithm effectively merges the parallelization strengths of ManySAT with the efficiency of MiniSat conflict-clause minimization. By fostering a collaborative environment, the solver is positioned to tackle a broader range of SAT instances with improved performance and faster convergence.

Let P be a Boolean satisfiability problem represented as a set of clauses in CNF form. Denote the set of parallel MiniSat instances as S = S1, S2, . . . , Sn, where each instance explores a subset of the solution space Vi . The proof of convergence then looks like the following.

- Initial Conditions: Each instance Si maintains a local set of learned clauses Ci . In the beginning this is empty, but upon encountering a conflict, each instance performs conflict analysis to derive a learned clause c.
- Step 1: Clause Sharing Mechanism. When an instance Si generates a learned clause c from a conflict, it shares this clause with all other instances in S. This sharing mechanism ensures that all instances benefit from the conflicts encountered by any single instance.
- Step 2: Dynamic Search Space Pruning. After receiving the learned clause c, each instance updates its remaining search space Ri . This process can be expressed as: $R' i = Ri \cap \neg Ci$ (where $\neg Ci$ are the negations of the learned clauses). By incorporating the shared learned clauses, each instance effectively reduces its search space, leading to: $R' i \subset Ri$ .
- Step 3: Impact of Heuristic. The heuristic H influences the decision-making process. By prioritizing clauses and variables based on their activity and frequency, instances can reduce the expected number of decisions D made to reach a solution: $D' = D - \Delta DH$ where $\Delta DH$ represents the reduction in decisions achieved through heuristic guidance.
- Step 4: Reduction in Decisions and Conflicts The pruning of the search space directly impacts the decision-making process. Let D represent the number of decisions made by an instance to reach a solution. The expected number of decisions after sharing learned clauses becomes: $D' = D - \log(\Delta D)$ where $\Delta D$ represents the reduction in decisions due to improved clause sharing. As $\Delta D$ decreases the number of conflicts decears.
- Step 5: Accelerated Convergence. The cumulative effect of shared learned clauses and reduced search spaces leads to faster convergence. As the instances navigate a more constrained search environment, the overall time to reach a satisfying assignment decreases. Thus, we can express convergence towards a solution as: $\lim t \to \infty P(SAT) \to 1$

(where P(SAT) is the probability of finding a solution). The integration of ManySAT cooperative search with MiniSat conflict-clause minimization results in quicker convergence towards solutions. The collaborative nature of the algorithm enhances the efficiency of the SAT solving process by reducing the search space and minimizing conflict occurrences.

In the context of our project, the gender dimension (i.e., sex and/or gender analysis) has been carefully considered. However, based on the nature of the research and innovation activities planned, we conclude that gender-specific factors are not directly relevant to the project's core objectives or methodology. The project's focus is on [insert specific technical/scientific focus, e.g., software development, chemical

processes, data analysis, etc.], which inherently does not involve biological or social/cultural factors related to gender.

Given this scope, integrating a sex or gender analysis would not substantively impact the research outcomes or innovation processes we intend to pursue. Should future stages of the project reveal any unforeseen implications for gender, we are committed to reassessing this position and incorporating relevant gender perspectives accordingly.

In our project, we are committed to integrating open science practices as an essential part of our methodology. We have identified several open science practices that align with our objectives and will enhance the project's transparency, accessibility, and impact. We plan to give a presentation, and we explain our core findings. We also include every test result.

- Research **data management and management of other research outputs:**

During this project we have not used any other research outputs. However we have used MiniSAT and ManySAT algorithms for making comparisons to our algorithm.

#@CON-MET-CM@# #@COM-PLE-CP@#

## 2. Impact #@IMP-ACT-IA@#

***Impact – aspects to be taken into account.***

- Credibility of the pathways to achieve the expected outcomes and impacts specified in the work programme, and the likely scale and significance of the contributions due to the project.
- Suitability and quality of the measures to maximise expected outcomes and impacts, as set out in the dissemination and exploitation plan, including communication activities.

The newly developed SAT algorithm introduces a more efficient approach to solving SAT problems, a cornerstone in various computational fields such as optimization, verification. By significantly reducing computation time and resource requirements, this algorithm is poised to impact applications ranging from software verification to complex decision-making systems. The enhanced efficiency will directly contribute to achieving the expected outcomes in the work programme by advancing computational techniques critical to industry and research, potentially setting a new benchmark for SAT-solving capabilities.

## 2.1 Project's pathways towards impact

- Provide a **narrative** explaining how the project's results are expected to make a difference in terms of impact, beyond the immediate scope and duration of the project. The narrative should include the components below, tailored to your project.

  (a) Describe the unique contribution your project results would make towards (1) the **outcomes** specified in this topic, and (2) the **wider impacts**, in the longer term, specified in the respective destinations in the work programme.

Our SAT algorithm project is expected to drive significant advancements in computational efficiency across various disciplines, with lasting impacts that extend beyond the immediate scope and duration of the project. By offering a faster, more resource-efficient approach to solving satisfiability problems, the project stands to influence the following areas:

From a technological and economic perspective, our SAT algorithm can help drive efficiency across industries, reducing computational costs and resource consumption for high-demand tasks:

- By lowering the time and resource requirements of complex calculations, the algorithm supports industries in achieving greater efficiency, potentially decreasing operational costs and enhancing profitability.
- It will also promote the development of new products, services, and business processes reliant on advanced problem-solving algorithms, such as those used in verification processes for hardware and software or in cryptographic security.

Target groups: Industries relying on optimization and verification processes (e.g., electronics, manufacturing, cybersecurity, and finance) and software developers who can integrate this algorithm to improve the efficiency of commercial and industrial applications.

(b) Give an indication of the scale and significance of the project's contribution to the expected outcomes and impacts, should the project be successful. Provide quantified estimates where possible and meaningful.

If successful, the new SAT algorithm has the potential to significantly impact a broad range of industries and scientific fields due to its versatility and applicability across computational challenges. Here's an estimation of the reach and effect of the project:

- In the academic field, SAT solvers are central to computer science and related research areas, with over 200 universities and research institutions globally engaged in SAT research and applications. By offering an open-access version, the algorithm could potentially be adopted by a third of these institutions in the first three years post-release, reaching approximately 70 universities or research centers, accelerating research efforts in fields like cryptography, and optimization.

(c) Describe any requirements and potential barriers - arising from factors beyond the scope and duration of the project - that may determine whether the desired outcomes and impacts are achieved. These may include, for example, other R&I work within and beyond Horizon Europe; regulatory environment; targeted markets; user behaviour. Indicate if these factors might evolve over time. Describe any mitigating measures you propose, within or beyond your project, that could be needed should your assumptions prove to be wrong, or to address identified barriers.

We have no requirements for this research project, that why We also could not identify any relevant barriers.

**2.2 Measures to maximise impact - Dissemination, exploitation and communication** #@COM-DIS-VIS-CDV@#

- Describe the planned measures to maximise the impact of your project by providing a first version of your 'plan for the dissemination and exploitation including communication activities'. Describe the dissemination, exploitation and communication measures that are planned, and the target group(s) addressed (e.g. scientific community, end users, financial actors, public at large).

- Outline your strategy for the management of intellectual property, foreseen protection measures, such as patents, design rights, copyright, trade secrets, etc., and how these would be used to support exploitation.

We are patenting the algorithmic model. The research could be used for scientific goals, but it would be our interest to have the rights over algorithm.

Most of those researchers could use our algorithm who works on domains of Hardware and Software verification, Code optimization, Automated planning and Cryptography. Mainly academic researchers and members through the industry could find the algorithm useful.
The research could be promoted with demonstrations and presentations. These events can be held in universities where most researchers would be able to learn about our project. Also, live podcasts can be done where for instance academic researchers could ask about the topic.
Presentations could also be given in some company campuses. Researchers in company domains could get on with the algorithm and they may use it, evolve it or join our research group.
On our official website anyone could give our research team feedback. Our email address is available and an online form as well.

Throughout the research no copyright content was needed.

#§COM-DIS-VIS-CDV§#

**2.3 Summary**

## KEY ELEMENT OF THE IMPACT SECTION

| SPECIFIC NEEDS | EXPECTED RESULTS | D & E & C MEASURES |
|---|---|---|
| *What are the specific needs that triggered this project?*<br><br>Example 1<br>Efficient way of solving SAT problem, which is an NP-complete problem. Our first thoughts, can we make a more resource efficient algorithm. | What do you expect to generate by the end of the project?<br><br>Example 1<br>**A fast $n^2$ computation cost algorithm** that more efficient than the existing SAT solvers, such as DPLL or CDCL.<br><br>Example 2<br>Our other goal is the development an algorithm that despite **NP-completeness** it solves big SAT instances in a reasonable amount of time. | What dissemination, exploitation and communication measures will you apply to the results?<br><br>Example 1<br>**Exploitation:** Patenting the algorithmic model.<br><br>**Dissemination towards the scientific community and industry:** Participating at conferences; Developing a platform of material compositions for industry |

| TARGET GROUPS | OUTCOMES | IMPACTS |
|---|---|---|
| *Who will use or further up-take the results of the project? Who will benefit from the results of the project?*<br><br>Example 1<br>**Academic researchers**<br><br>**Researchers in the industry**<br><br>**Other college members** | *What change do you expect to see after successful dissemination and exploitation of project results to the target group(s)?*<br><br>Example 1<br>**High use of the scientific discovery published**<br><br>Using **less energy** for SAT solving via planet Earth | *What are the expected wider scientific, economic and societal effects of the project contributing to the expected impacts outlined in the respective destination in the work programme?*<br><br>Example 1<br>**Scientific:** New breakthrough scientific discovery on **NP-complete** problems.<br><br>**Economic:** Using less energy and time.<br><br>**Research domains**: Hardware and Software verification, Code optimization, automation and cryptography. |

#§IMP-ACT-IA§#

## 3. Quality and efficiency of the implementation #@QUA-LIT-QL@# #@WRK-PLA-WP@#

***Quality and efficiency of the implementation – aspects to be taken into account***

- *Quality and effectiveness of the work plan, assessment of risks, and appropriateness of the effort assigned to work packages, and the resources overall*
- *Capacity and role of each participant, and extent to which the consortium as a whole brings together the necessary expertise.*

### 3.1 Work plan and resources

#§CON-SOR-CS§# #§PRJ-MGT-PM§#

**Table 3.1a: List of work packages**

| Work package No | Work Package Title | Lead Participant No | Lead Participant Short Name | Person-Months | Start Month | End month |
|---|---|---|---|---|---|---|
| WP1 | Project Management | 1 | ELTE | 4 | 1 | 6 |
| WP2 | Background Research and Information Collection | 1 | ELTE | 4 | 1 | 1 |
| WP3 | Algorithm Development | 1 | ELTE | 10 | 2 | 3 |
| WP4 | Validation and Testing | 1 | ELTE | 8 | 4 | 5 |
| WP5 | Communication and Dissemination | 1 | ELTE | 4 | 6 | 6 |

**Table 3.1b: Work package description**

**For each work package:**

| | |
|---|---|
| **Work package number** | WP1 |
| **Work package title** | Project Management |

**Objectives**

The objective of this work package is to manage the project, the human and physical resources, and to monitor the progress of the project.

**Description of work**

Only ELTE is responsible for this work package.

The purpose of the work package is to ensure that all phases of the project are completed on time and within the specified deadlines. Communication between participants must be ensured. Human resources management, which includes the selection of the necessary specialists (e.g. researchers, developers) and the optimal distribution of their workload. Providing the necessary tools and technological infrastructure for the project (e.g. research tools, office premises).

| | |
|---|---|
| **Work package number** | WP2 |
| **Work package title** | Background Research and Information Collection |

**Objectives**

Explore the results achieved so far in the field of SAT solving and parallel algorithms. Plan the research.

**Description of work**

Only ELTE is responsible for this work package.

Explore the history of SAT problem, get to know the fields of application of SAT solvers. Examine the algorithms known so far, like DPLL, CDCL algorithms, MiniSAT and ManySAT. Explore parallel algorithms and learn how these split the search across multiple processors to reduce the execution time. Examine the weaknesses of the existing algorithms.

Moreover, this work package contains the planning of the research, and the algorithm based on the collected information.

| | |
|---|---|
| **Work package number** | WP3 |
| **Work package title** | Algorithm Development |

**Objectives**

Create our algorithm.

**Description of work**

ELTE cooperates with ETH in this work package. The algorithm has to be specified, for this the following tasks required:

- create the algorithm with transfer the given formula for the correct form to analyse it,
- create the splitting strategies,
- decide the number of threads,

- decide what information will be shared between threads,
- collect heuristics
- runtime optimalization
- hardware usage optimalization.

| **Work package number** | WP4 |
|---|---|
| **Work package title** | Validation and Testing |

**Objectives**

Validate the correction of our algorithm and test it while running.

**Description of work**

ELTE cooperates with KU in validation and Microsoft helps ELTE to test the algorithm. During algorithm validation, we check whether the algorithm solves the given problem, as well as whether it is error-free and optimality from the perspective of performance. Runtime, computational cost and hardware usage need to be tested. Documentation also has to be written in this work package.

| **Work package number** | WP5 |
|---|---|
| **Work package title** | Communication and Dissemination |

**Objectives**

Introduce our results to the world.

**Description of work**

Only ELTE is responsible for this work package.

Our result has to be available by the researchers of the world. For this, we need to do following tasks:

- promote the research with demonstrations and presentations, for example in universities,
- create live podcasts where for instance academic researchers could ask about the topic,
- give presentations in some company campuses,
- create our official website where anyone could give our research team feedback (public email address and online form).

**Table 3.1c: List of Deliverables[2]**

Only include deliverables that you consider essential for effective project monitoring.

| Number | Deliverable name | Short description | Work package number | Short name of lead participant | Type | Dissemination level | Delivery date (in months) |
|---|---|---|---|---|---|---|---|
| 1 | Data management plan | Contains the plan | WP2 | ELTE | DMP | PU | 1 |
| 2 | Algorithm | The algorithm of the new SAT solver | WP3 | ELTE | Other (Algorithm) | PU | 3 |
| 3 | Software | The software that implements the algorithm | WP3 | ELTE | Other (Software) | PU | 4 |
| 4 | Documentation | The documentation of the algorithm and the software | WP4 | ELTE | R | PU | 5 |
| 5 | Dissemination plan | The plan for dissemination and communication | WP5 | ELTE | R | PU | 6 |

**KEY**
Deliverable numbers in order of delivery dates. Please use the numbering convention <WP number>.<number of deliverable within that WP>.
For example, deliverable 4.2 would be the second deliverable from work package 4.

**Type:**
Use one of the following codes:

R: Document, report (excluding the periodic and final reports)
DEM: Demonstrator, pilot, prototype, plan designs
DEC: Websites, patents filing, press & media actions, videos, etc.
DATA: Data sets, microdata, etc.
DMP: Data management plan
ETHICS: Deliverables related to ethics issues.
SECURITY: Deliverables related to security issues
OTHER: Software, technical diagram, algorithms, models, etc.

**Dissemination level:**
Use one of the following codes:

PU – Public, fully open, e.g. web (Deliverables flagged as public will be automatically published in CORDIS project's page)
SEN – Sensitive, limited under the conditions of the Grant Agreement
Classified R-UE/EU-R – EU RESTRICTED under the Commission Decision No2015/444
Classified C-UE/EU-C – EU CONFIDENTIAL under the Commission Decision No2015/444
Classified S-UE/EU-S – EU SECRET under the Commission Decision No2015/444

**Delivery date**
Measured in months from the project start date (month 1)

Table 3.1d: List of milestones

| Milestone number | Milestone name | Related work package(s) | Due date (in month) | Means of verification |
|---|---|---|---|---|
| 1 | Data management plan | WP2 | 1 | All needed data are available. |
| 2 | Algorithm | WP3 | 2 | Prove the correctness of the algorithm. |
| 3 | Software | WP3, WP4 | 4 | Validate the software with tests, |
| 4 | Documentation | WP4 | 5 | Every important increment is documented. |
| 5 | Dissemination plan | WP5 | 6 | The foundation of the research has been spread widely. |

**KEY**

**Due date**

Measured in months from the project start date (month 1)

**Means of verification**

Show how you will confirm that the milestone has been attained. Refer to indicators if appropriate. For example: a laboratory prototype that is 'up and running'; software released and validated by a user group; field survey complete and data quality validated.

**Table 3.1e: Critical risks for implementation** #@RSK-MGT-RM@#

| Description of risk (indicate level of (i) likelihood, and (ii) severity: Low/Medium/High) | Work package(s) involved | Proposed risk-mitigation measures |
|---|---|---|
| Proving the correctness of the algorithm is not possible. Likelihood to occur is high, level of severity is also high, | Creating the algorithm. | Try to make an algorithm, that is correct. Avoid solutions that is not deterministic. |
| The algorithm will not work deterministically in all programing languages. Level of likelihood is low, but severity level is medium. | Software implementation. | Try to avoid programing language specific solutions. |

**Definition critical risk:**

A critical risk is a plausible event or issue that could have a high adverse impact on the ability of the project to achieve its objectives.

**Level of likelihood to occur: Low/medium/high**

The likelihood is the estimated probability that the risk will materialise even after taking account of the mitigating measures put in place.

**Level of severity: Low/medium/high**

The relative seriousness of the risk and the significance of its effect.

#§RSK-MGT-RM§#

**Table 3.1f: Summary of staff effort**

| | WP1 | WP2 | WP3 | WP4 | WP5 | Total Person-Months per Participant |
|---|---|---|---|---|---|---|
| **1 ELTE** | **4** | **4** | **4** | **2** | **4** | 4 |
| **2 ETH** | 0 | 0 | 6 | 0 | 0 | 6 |
| **3 KU** | 0 | 0 | 0 | 3 | 0 | 3 |
| **4 Microsoft** | 0 | 0 | 0 | 3 | 0 | 3 |
| **Total Person Months** | 4 | 4 | 10 | 8 | 4 | |

**Table 3.1g: 'Subcontracting costs' items**

| Participant Number/Short Name | | |
|---|---|---|
| | **Cost (€)** | **Description of tasks and justification** |
| **1 ELTE** | 3200 | Create, validate and test the algorithm, and dissemination. |
| **2 ETH** | 1600 | Create the algorithm. |
| **3 KU** | 1600 | Validate the algorithm. |
| **4 Microsoft** | 1600 | Test the algorithm, |

**Table 3.1h: 'Purchase costs' items (travel and subsistence, equipment and other goods, works and services)**

| Participant Number/Short Name | | |
|---|---|---|
| | **Cost (€)** | **Justification** |
| **Travel and subsistence** | 80 | Local public transportation is required to transport the members. |
| **Equipment** | 2000 | Personal computers are needed for the implementation part. |
| **Other goods, works and services** | 120 | Food supply is needed for the team. |
| **Remaining purchase costs (<15% of pers. Costs)** | 60 | |
| **Total** | 2260 | |

**Table 3.1i: 'Other costs categories' items (e.g. internally invoiced goods and services)**

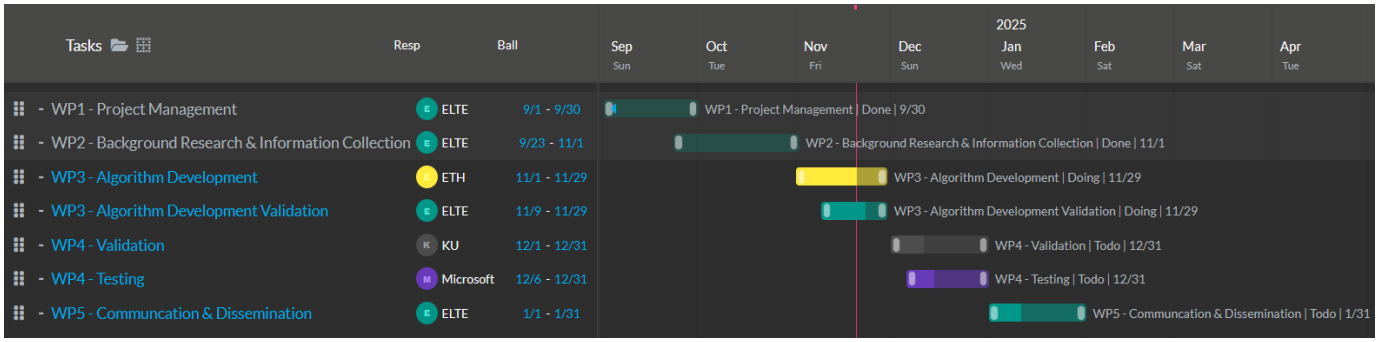
| 1 Péter | | |
|---|---|---|
| | **Cost (€)** | **Justification** |
| **Internally invoiced goods and services** | 1000 | Renting the workplace. |
| **Internally invoiced goods and services** | 100 | Overhead of the workplace. |
| **...** | | |

**Table 3.1j: 'In-kind contributions' provided by third parties**

| Pa1 Péter | | | |
|---|---|---|---|
| **Third party name** | **Category** | **Cost (€)** | **Justification** |
| Eötvös Loránd University | Seconded personnel<br>**Select between**<br>Seconded personnel<br>Travel and subsistence<br>Equipment<br>Other goods, works and services<br>Internally invoiced goods and services | 20 | Maintain workplace. |
| Microsoft | Equipment | 200 | Renting equipment, such as laptops. |

#§QUA-LIT-QL§# #§WRK-PLA-WP§#

## 3.2 Capacity of participants and consortium as a whole #@CON-SOR-CS@# #@PRJ-MGT-PM@#



**ANNEXES TO PROPOSAL PART B**

For the proposal of our SAT solver algorithm, we have considered the potential need for annexes to Proposal Part B, as outlined in the Horizon Europe guidelines. These annexes are essential for providing supplementary details in areas where the main proposal sections may have space limitations or where specific, detailed information is required.

In the context of our research:

- **Ethics**: Although our ethics self-assessment will be included in Proposal Part A, we recognize that additional information may be needed. If the character limit in Part A is insufficient to convey all ethical considerations related to our research, we will provide a comprehensive annex in Part B. This annex will address any potential ethical implications of the algorithm's development and application, ensuring adherence to Horizon Europe’s ethics standards.
- **Security Considerations**: If flagged as necessary, we will include an annex detailing any security-sensitive aspects of the project, outlining measures to mitigate potential risks and ensure compliance with security protocols.
- **Financial Support to Third Parties and Clinical Trials**: While these areas are not directly relevant to our current proposal focused on algorithmic research, should future project phases involve partnerships or funding distribution, the relevant annexes will be prepared in accordance with Horizon Europe requirements.

These additional documents will be uploaded as separate annexes in the submission system, ensuring the proposal meets all compliance and evaluation standards.