Technical Design Paper Instructions & Template  
for the 2022 RobotX Competition

First A. TeamMember, Second B. TeamMember, and Third C. TeamMember

*Abstract*—This paper is both an instruction document and template to be used in preparation of RobotX technical design papers. The goals of the RobotX technical design paper are to assist teams in becoming more familiar with the preparation of scientific publications, to articulate the linkage between vehicle design tradeoffs and overall competition strategy, and to document successful approaches and lessons learned for future team members. If using Microsoft Word, text may be entered directly into this template; otherwise, authors should adhere to this instruction as close as possible. This template is based on the IEEE Transactions standard, and authors desiring to use LaTeX may retrieve similar style files from the IEEE website ([www.ieee.org](http://www.ieee.org)).

# INTRODUCTION

The purpose of the RobotX competition is to enhance the community of innovators capable of substantive contributions to the domain of autonomous unmanned systems. This enhancement is achieved by providing a venue and mechanism whereby the practitioners of the autonomous systems community may form new connections and collaborations, increase their proficiency and inventiveness, and foster their passion for robotics in the maritime domain.

# Paper Preparation & Style Guidelines

Teams should download the Team Handbook from the RobotX website ([www.robotx.org/2022](http://www.robotx.org/2022)) website for due dates and submission instructions. The format of the technical design paper shall adhere to the following guidelines, which are also utilized in this template document:

* 8.5 x 11 in. paper
* Double column style
* 10 page limit (excluding References & Appendix)
* Submitted in pdf format
* Margins ≥ 0.8 in.
* Header on every page including team name and page number
* Font: Times New Roman font using sizes as described in Table I

Most fields of study have their own styles while all scientific and technical writing follows similar guidelines. The style for the RobotX technical design paper follows the IEEE Transactions paper template, which is typical for many fields of engineering. The full IEEE template is referenced in the Appendix, and those who have not published significantly or do not have English as a first language are encouraged to read this instruction in its entirety for general best practices in scientific writing.



Font guidelines.

These fonts are included as styles in this MS-Word template. Note that a table caption goes above the table whereas a figure caption goes below the figure.

|  |  |
| --- | --- |
| Text Location | Font |
| Title | 24 pt. |
| Author Names | 10 pt. |
| Abstract | 9 pt., bold |
| Heading, Level 1 | 10 pt., centered, small caps, Roman numbering |
| Heading, Level 2 | 10 pt. italic, capital letter numbering |
| Heading, Level 3 | 10 pt. italic, Arabic numbering |
| Body Text | 10 pt. |
| Figure Caption | 8 pt. below figure |
| Table Caption | 8 pt., small caps above table |
| References | 8 pt. |

As a minimum set of guidelines, define abbreviations and acronyms the first time they are used, and use a zero before decimal points (*e.g.,* 0.5 rather than .5). Contractions should be avoided (*e.g.,* write “will not” vice “won’t”) and use the serial comma prior to the word “and” in a list (*e.g.,* x, y, and z). Italics should be used for emphasis rather than quotation marks (*e.g.,* do *this* and not “this”), and authors using common Latin abbreviations should clearly understand their meaning as their misuse confuses the reader. For example,

* “*e.g.,*” means “for example,”
* “*i.e.,*” means “that is,”
* “*cf.*” requests that the reader compare something you just said with what you’re about to say.

Note that in formal scientific writing words from languages other than English (whether abbreviated or not) should be italicized. A single “-” is a *hyphen* and is used to join two modifiers (without spaces) that would not make sense if used alone (*e.g.,* “a well-written sentence”) whereas two “-” are typically turned into a “—” by most word processors and constitutes a *dash*. The dash should not be used to replace the comma, and it should be used very sparingly in professional writing. Scientific writing should always utilize a third person (and preferably active voice) and avoid first or second person (e.g., say “The vehicle is programmed to…” rather than “I/we programmed the vehicle to…”).

Equations should be numbered consecutively, placed in line with text (using appropriate punctuation) and cited using numerical reference (*e.g.,* “The result of (1) is that…”). Additionally, symbols should be explained immediately following the equation.

|  |  |
| --- | --- |
| , | (1) |

Figures should also be referred to in line with text as in “The data in Fig 1 shows that…”, and they should appear in the document only after they have been referenced in the text.

# Paper Contents

The technical design paper consists of the following mandatory sections and two optional sections (Acknowledgements and Appendix). Additional sections may be included; however, the overall limit of 10 pages applies to all sections—the only exceptions are the References and Appendix.

## Design Strategy

This section should discuss how the team generally plans on approaching the competition challenges and overall Autonomy Challenge, with discussion of how the system design relates to this approach. Additionally, teams should discuss how their design choices address the tradeoffs of reliability vs. complexity as well as capability vs. robustness. For example, teams have a limited number of working hours to prepare for the competition; this time could be spent adding additional capability or testing and improving the reliability of the existing capability. Equivalently, teams may choose to include increasingly sophisticated capability on their unmanned systems; however, additional sophistication (especially on maritime systems) represents additional failure points and often impacts reliability.

## Vehicle Design

In the past, this section (e.g., mechanical, electrical, and software) constituted the bulk of the technical design paper and was often used by teams primarily to catalogue their component choices and resulting design. While the technical design paper should still describe the design, the RobotX judges would like to encourage teams to increase emphasis on the following:

* Design processes and methodologies employed and their impact on component choices and design results
* Lessons learned from design iterations, testing evolutions, and/or experience at prior competitions. This should also include insight into designs, processes, or practices that did *not* work and should be avoided in the future
* Algorithmic descriptions or software approaches that the team has found to be particularly useful, impactful, or novel as well as any system engineering endeavors pursued by the team that should be continued or refined.

In short, the teams should consider the technical design paper as not only an opportunity to practice scientific writing and advocate for their RobotX entry, but they should also consider it a means to document and transfer knowledge to their future team members.



1. Both axes of a figure *must* be labeled and the caption should be used to explain why the figure is important to the reader (*i.e.,* do not simply use the caption to name the figure). Note that a figure caption goes below the figure whereas a table caption goes above the table.

## Experimental Results

This section should briefly describe how the team accomplishes testing (*e.g.,* in-water, simulation, etc.) and provide some notion of how much testing has occurred as of the technical design paper submission. Note that the *actual results* reported in this section will not affect the team’s technical design paper score (*e.g.,* reporting a large or small number of in-water hours will neither help nor hurt the technical design paper score). This section should also discuss any studies, calculations, or estimates that the team has performed in the areas of reliability and robustness (e.g., failure analysis, reliability modeling, structural analysis, etc.).

## Acknowledgements (optional)

This is an optional section that teams may wish to utilize to acknowledge particular assistance, sponsors, etc.

## References

As with any scientific publication, original ideas and content that are not generated by the paper’s authors should be properly cited. While there are several reference styles, the RobotX technical design paper uses the IEEE style, which is detailed in the Appendix. This style uses the bracketed reference, which should be used in line with text as in “The work in [x] states that…” This section does not count against the page limit.

## Appendix—Situational Awareness (optional)

The Appendix is optional and does not count against the page limit. Recall that a foundational purpose of RobotX is to strengthen and enhance the community. Therefore teams are encouraged to share their approaches to solving operational concerns relevant to the unmanned systems community. A significant challenge to adoption of unmanned systems is user trust. Human users have a need to understand what the unmanned system is doing and why; users must have confidence that the system is behaving as intended. This is particularly important as emergent behaviors become more common. Discuss how you would approach providing information to users such that they would have awareness of the unmanned systems situation, and thus confidence in the unmanned systems intentions. Although this appendix is optional, a special award could be designated for this topic.

# Appendix

This Appendix is taken from the IEEE Transactions template on the IEEE website, and should be followed for citing references, (<https://template-selector.ieee.org/secure/templateSelector/publicationType>).

*Basic format for books:*

1. J. K. Author, “Title of chapter in the book,” in *Title of His Published Book, x*th ed. City of Publisher, Country if not
2. USA: Abbrev. of Publisher, year, ch. *x*, sec. *x*, pp. *xxx–xxx.*

*Examples:*

1. G. O. Young, “Synthetic structure of industrial plastics,” in *Plastics,* 2nd ed., vol. 3, J. Peters, Ed. New York: McGraw-Hill, 1964, pp. 15–64.
2. W.-K. Chen, *Linear Networks and Systems.* Belmont, CA: Wadsworth, 1993, pp. 123–135.

*Basic format for periodicals:*

1. J. K. Author, “Name of paper,” *Abbrev. Title of Periodical*, vol. *x,* no. *x,* pp*. xxx-xxx,* Abbrev. Month, year.

*Examples:*

1. J. U. Duncombe, “Infrared navigation—Part I: An assessment   
   of feasibility,” IEEE *Trans. Electron Devices*, vol. ED-11, no. 1, pp. 34–39, Jan. 1959.
2. E. P. Wigner, “Theory of traveling-wave optical laser,” *Phys. Rev*.,   
   vol. 134, pp. A635–A646, Dec. 1965.
3. E. H. Miller, “A note on reflector arrays,” *IEEE Trans. Antennas Propagat*., to be published.

*Basic format for reports:*

1. J. K. Author, “Title of report,” Abbrev. Name of Co., City of Co., Abbrev. State, Rep. *xxx*, year.

*Examples:*

1. E. E. Reber, R. L. Michell, and C. J. Carter, “Oxygen absorption in the earth’s atmosphere,” Aerospace Corp., Los Angeles, CA, Tech. Rep. TR-0200 (4230-46)-3, Nov. 1988.
2. J. H. Davis and J. R. Cogdell, “Calibration program for the 16-foot antenna,” Elect. Eng. Res. Lab., Univ. Texas, Austin, Tech. Memo. NGL-006-69-3, Nov. 15, 1987.

*Basic format for handbooks:*

1. *Name of* Manual*/*Handbook, *x* ed., Abbrev. Name of Co., City of Co., Abbrev. State, year, pp. *xxx-xxx.*

*Examples:*

1. *Transmission Systems for Communications*, 3rd ed., Western Electric Co., Winston-Salem, NC, 1985, pp. 44–60.
2. *Motorola Semiconductor Data Manual*, Motorola Semiconductor Products Inc., Phoenix, AZ, 1989.

*Basic format for books (when available online):*

1. Author. (year, month day). *Title.* (edition) [Type of medium]. *volume (issue).* Available: site/path/file

*Example:*

1. J. Jones. (1991, May 10). *Networks.* (2nd ed.) [Online]. Available: [http://www.atm.com](http://www.atm.com/)

*Basic format for journals (when available online):*

1. Author. (year, month). Title. *Journal.* [Type of medium]. *volume (issue),* pages. Available: site/path/file

*Example:*

1. R. J. Vidmar. (1992, Aug.). On the use of atmospheric plasmas as electromagnetic reflectors. *IEEE Trans. Plasma Sci.* [Online]. *21(3),* pp. 876–880. Available:<http://www.halcyon.com/pub/journals/21ps03-vidmar>

*Basic format for papers presented at conferences (when available online):*

1. Author. (year, month). Title. Presented at Conference title. [Type of Medium]. Available: site/path/file

*Example:*

1. PROCESS Corp., MA. Intranets: Internet technologies deployed behind the firewall for corporate productivity. Presented at   
   INET96 Annual Meeting. [Online]. Available: <http://home.process.com/Intranets/wp2.htp>

*Basic format for reports and handbooks (when available online):*

1. Author. (year, month). Title. Comp an y . C ity, State or Country. [Type of Medium]. Available: site/path/file

*Example:*

1. S. L. Tall een. (1996 , Apr . ). The In t r an et Archi -tecture: M a nagi ng i n f o rm at i on i n t h e ne w paradigm. Amdahl Corp., CA. [Online]. Available:<http://www.amdahl.com/doc/products/bsg/intra/infra/html>

*Basic format for computer programs and electronic documents (when available online):* ISO recommends that capitalization follow the accepted practice for the language or script in which the information is given.

*Example:*

1. A. Harriman. (1993, June). Compendium of genealogical software. *Humanist.* [Online]. Available e-mail: [HUMANIST@NYVM.ORG](mailto:HUMANIST@NYVM.ORG) Message: get GENEALOGY REPORT

*Basic format for patents (when available online):*

1. Name of the invention, by inventor’s name. (year, month day). *Patent Number* [Type of medium]. Available: site/path/file

*Example:*

1. Musical toothbrush with adjustable neck and mirror, by L.M.R. Brooks. (1992, May 19). *Patent D 326 189*

[Online]. Available: NEXIS Library: LEXPAT File: DESIGN

*Basic format for conference proceedings (published):*

1. J. K. Author, “Title of paper,” in *Abbreviated Name of Conf.*, City of Conf., Abbrev. State (if given), year, pp. *xxxxxx.*

*Example:*

1. D. B. Payne and J. R. Stern, “Wavelength-switched pas- sively coupled single-mode optical network,” in *Proc. IOOC-ECOC,* 1985,   
   pp. 585–590.

*Example for papers presented at conferences (unpublished):*

1. D. Ebehard and E. Voges, “Digital single sideband detection for interferometric sensors,” presented at the 2nd Int. Conf. Optical Fiber Sensors, Stuttgart, Germany, Jan. 2-5, 1984.

*Basic format for patents:*

1. J. K. Author, “Title of patent,” U.S. Patent *x xxx xxx*, Abbrev. Month, day, year.

*Example:*

1. G. Brandli and M. Dick, “Alternating current fed power supply,”   
   U.S. Patent 4 084 217, Nov. 4, 1978.

*Basic format**for theses (M.S.) and dissertations (Ph.D.):*

1. J. K. Author, “Title of thesis,” M.S. thesis, Abbrev. Dept., Abbrev. Univ., City of Univ., Abbrev. State, year.
2. J. K. Author, “Title of dissertation,” Ph.D. dissertation, Abbrev. Dept., Abbrev. Univ., City of Univ., Abbrev. State, year.

*Examples:*

1. J. O. Williams, “Narrow-band analyzer,” Ph.D. dissertation, Dept. Elect. Eng., Harvard Univ., Cambridge, MA, 1993.
2. N. Kawasaki, “Parametric study of thermal and chemical nonequilibrium nozzle flow,” M.S. thesis, Dept. Electron. Eng., Osaka Univ., Osaka, Japan, 1993.

*Basic format for the most common types of unpublished references:*

1. J. K. Author, private communication, Abbrev. Month, year.
2. J. K. Author, “Title of paper,” unpublished.
3. J. K. Author, “Title of paper,” to be published.

*Examples:*

1. A. Harrison, private communication, May 1995.
2. B. Smith, “An approach to graphs of linear forms,” unpublished.
3. A. Brahms, “Representation error for real numbers in binary computer arithmetic,” IEEE Computer Group Repository, Paper R-67-85.

*Basic format for standards:*

1. *Title of Standard*, Standard number, date.

*Examples:*

1. IEEE Criteria for Class IE Electric Systems, IEEE Standard 308, 1969.
2. Letter Symbols for Quantities, ANSI Standard Y10.5-1968.