The Future of Command and Control

History of the ICCRTS

In 1995, the US DoD Command and Control Research Program (CCRP), within the Office of the Secretary of Defense, organized the first International Command and Control Research and Technology Symposium (ICCRTS) at the National Defense University in Washington, D.C. This meeting was built upon a series of meetings organized during the 1970s by the Office of Naval Research and the Massachusetts Institute of Technology that brought together interested researchers to exchange ideas on command and control (C2), its measurement and assessment, and the impact of new technologies on C2 processes. The 1995 event was also arguably a follow-on to a similar international event held at Eynsham Hall, Oxford UK in 1994, on C2 and Information Systems Research. This event was supported by both the UK Defence Research Agency and the US Joint Directors of Laboratories.

While the initial ICCRTS meeting was modest in size and included only a handful of non-U.S. participants, the event has grown substantially over the years to include participants from many nations. This Symposium series provides an unparalleled opportunity for professional researchers, academics, active duty and reserve officers, and policymakers to interact with one another to discuss future challenges and concepts, understand the current state of the art, and influence future thinking and practice across coalition partners.

ICCRTS has evolved to include (a) leading-edge concepts in C2 (b) new science and technology and their potential impact on C2 and the conduct of Multi-Domain Operations, and (c) feedback and evidence from experiments, exercises, and real-world operations. The Symposium is also an important forum for discussion of coalition and collective C2 issues and for examining the challenges emerging from complex endeavors (i.e. hybrid warfare, counter terrorism, stabilization, operations, disaster relief), that involve a variety of entities including military, civilian, government, international organizations, Private Voluntary Organizations (PVOs) and
Non-Governmental Organizations (NGOs).

In 2015, a true test of the value of this activity emerged when Government funds were no longer available to cover the costs of organizing and administering the Symposium. The challenge to the C2 Research Community was to find a way for this event to survive as an independent activity. Ultimately, it would require the combined efforts of the international research community to ensure that its annual symposium and the body of literature associated with the CCRP would endure without direct Government funding. The fact that this did indeed happen provides evidence of the importance of this resource and opportunity to the community.

In 2016, the non-profit International Command and Control Institute (IC2I) assumed responsibility for the organization and running of future ICCRTS as well as the responsibility for hosting the research community’s website and research archives. This website can be found at: http://internationalc2institute.org

The 25th ICCRTS finds the event back in the UK and hosted by the UK’s Defence Science and Technology Laboratory (Dstl). Not counting the non-ICCRTS 1994 C2 event, this will be the third time that ICCRTS has been held in the United Kingdom (previous events being London 2016 and Cambridge 2006). ICCRTS has been held in other international locations including: Australia (2000), Canada (2002, 2011), and Denmark (2004).

**Theme: The Future of Command and Control**

ICCRTS themes, over the years, have served to highlight many C2 related challenges that need attention. The theme for this, the 25th ICCRTS, is appropriately a call for reflection: to look back at which of these challenges were foremost in our minds a quarter of a Century ago; to assess the extent that the C2 research and development community has developed the theory, concepts, and research findings that have served to drive changes to our organizations, doctrines, processes, and systems capabilities; to identify how these challenges have evolved over the years and determine the extent to which our advice and ‘solutions’ remain fit for purpose; and, to look ahead to establish our priorities going forward so we can focus on the critical C2 related challenges of today and tomorrow.

In 1995, when the 1st ICCRTS was held at the National Defense University in Washington, DC, we were concerned about two major issues. The first was the implications of the capabilities associated with the emergence of the Information Age for our organizations and for command and control concepts and approaches. Attention was paid to both the enormous potential to create more effective and efficient ‘networked’ organizations as well as the implications of what was called ‘Information Warfare.’ The second was the need to work together in coalitions and whether or not our C2 concepts and approaches were up to the task.

In the last 25 years, the changes in the nature of the missions we face and the advances in and proliferation of information technologies have made meeting these twin challenges even more difficult. The Multi-Domain Operations of today involve: a more heterogeneous set of mission
partners; are more complex as a result of the inter-dependencies that exist between and among operations in very different domains; and, must operate in highly contested environments. Being able to operate effectively in cyberspace, the information ‘domain’ and in space has today become even more critical to future mission success than it has been in the prior two decades.

Our terminology has also evolved with new terms entering our lexicon, most notably, ‘cyber’ and ‘cyberspace.’ Neither of these terms is viewed in quite the same way by different organizations and communities. For the purposes of ICCRTS, the term ‘cyber’ refers to the technical capabilities associated with our networked and information-enabled forces and cyberspace includes what has been previously called the information domain. The emergence of the ‘internet of things’ has been made possible by ‘cyber-enabled’ intelligent software, robotic, and autonomous systems capabilities. As with many of the topics ICCRTS encompasses, ‘cyber’ discussions could in principle include sensitive and classified topics and data. However, ICCRTS is, and will remain, a public forum, and thus contributors and attendees are reminded to limit their papers, presentations, and discussions to material that are in the Public Domain.

In recognition of these challenges, both plenaries and track sessions will focus on:

- The reality of conducting C2 in the ‘Information Age’ circa 2020-2050
- Twin Challenges to C2, simultaneously leveraging cyber and cyber-enabled capabilities while operating in cyber-contested environments, and the implications for necessary C2 properties (e.g. resilience, responsiveness, adaptability, innovativeness, proactivity)
- Working with others in Multi-Domain Operations
- Future Socio-Technical and leadership challenges for organizations (including human-machine teams and autonomous systems)
- Making sense of complexity with its associated uncertainty and unfamiliarity
- Determining C2 Mission Fitness (readiness, maturity, effectiveness, efficiency, agility)

**Topics of Interest**

ICCRTS seeks to encourage and publish Technical Papers of professional journal quality, reporting on research and analysis activities related to C2. The 25th ICCRTS event will be thus partly comprised of presentational tracks exploring the Symposium Theme from a number of different perspectives. Authors are thus requested to consider this year’s theme and the above proposed track topics as they prepare their technical and concept papers. It is recognized that these topic areas are not mutually exclusive and hence any one paper may address multiple of them. Therefore, papers will be assigned mostly on the basis of what the primary focus of the paper is, but authors should assist in proposing this. The above are proposals, with the eventual symposium tracks being developed based on the numbers and actual content of the papers submitted. In addition to the specific topics provided below, submissions that contribute to a critical examination of C2 related subjects are always welcome.

Initial paper abstracts are invited on the following topics:

**Topic 1: C2 in the Information Age**
This topic is intended to explore the full range of implications for C2 emerging from the need to operate in an era of increasingly sophisticated information technology and ubiquitous information environments. These implications arise from the fact that crisis and conflict now increasingly take place as much in a virtual information environment (aka cyberspace) as they do in the historic physical domains (land/maritime/air). Hence C2 needs to be able to understand, operate in, and influence activity in the full range of environments. This new context also affords new opportunities and threats for C2 e.g. it provides an opportunity to sense and understand more comprehensively what is happening in the external world, and at the same time opens up new routes to deception and vulnerability, especially if C2 capability becomes overly dependent on reliable connectivity and access to information.

Papers are therefore invited, that explore the C2 challenges arising from information being simultaneously an enabler of organizations and operations, a vulnerability due to over-dependency, and also a potential ‘lever of influence’ and ‘weapon’ to gain strategic or tactical advantage. Papers are also sought on concepts and potential mitigations for these challenges, some of which may suggest the need for entirely different approaches to C2, or alternatively extensive modifications to current practice being required, (potentially based on an analysis of the discrepancies between the current way of operating and these new demands).

**Topic 2: Multi-Domain and Coalition Command and Control**

There is an increasing realization that operations now require coherent and combined action to be taken across multiple domains. Arguably this is not a new discovery, but one that has been implicit in previous concepts including: effects based operations (EBO), comprehensive and integrated and approaches, Whole of Government and Coalition (WoG), and Joint Interagency Multinational (CJIM). Whilst the need for MDO has been discussed at least going back to the 1st ICCRTS, effective practice has lagged, and at the same time the need for even more coordination and coherency of activity and effects has emerged. This need is now embodied in the concept of multi-domain C2. Papers are therefore invited, which explore the need for, and developing the means to, work more effectively with a heterogeneous set of mission partners including Partners Across Government (PAGs), other nations’ military, civilian government, and non-governmental organizations, (NGOs) in order to plan, conduct and, harmonize both kinetic and non-kinetic operations in and across multiple domains. Please note that these domains include, but are not limited to, the traditional domains of warfare (land, sea, and air), the domains of space and cyberspace, and economic and social domains. Exemplar topics that papers could explore include (a) how to improve C2 organizations ability to work together, develop and sustain trust, (b) the implications for C2, when exploring the situation and planning operations across multiple domains and partners, and (c) the implications for information sharing and the use of visualisation within C2 organisations Also of interest would be any lessons learned in regard of assumed good practice for working with a mix of different mission partners including: Ministries, Departments, Bureaus, Agencies, Governments, Special Operations and Conventional Forces.
**Topic 3: Understanding and Coping with Complexity**

Conflict and crisis situations are now characterized by high complexity, high interconnectedness, high dynamics and non-linearity. Activities within these situations are also conducted simultaneously, by multiple actors (adversarial, supporting and neutral), and across multiple domains and environments. High interconnectedness combined with diversity of systems and actors, some of whom may intentionally be responding in irregular ways, will lead to surprising and unpredictable outcomes. Papers are therefore sought that either (a) explore how these characteristics impact our ability to understand situations, develop plans, and conduct operations, and/or (b) propose and assess effective mitigation strategies and techniques.

**Topic 4: Managing and Governing C2 as a holistic capability**

ICCRTS should, in theory, have been one of the catalysts for the transformation of C2 within the information age. However, there were some tentative observations noted at ICCRTS 2018, i.e. that (i) C2 ‘in practice’ has not substantially altered over the last few decades, relative to the substantial changes that have taken place in other elements of defense capability and (ii) the question of why this may be the case and what could be done about it has arguably been missing from ICCRTS consideration. This topic therefore seeks to address this observation. A current hypothesis for this problem has emerged is that C2 has historically not been considered, nor managed or governed, as a military capability in its own right. Papers are therefore sought on the topics of (a) objective observations and assessments of change and transformations in C2 practice, (b) observations, lessons and insights from any C2 transformation initiatives, (c) explorations into blockers/challenges for C2 transformation, (d) potential mitigation strategies and approaches to address identified challenges, (e) challenges, concepts and insights from any emerging approaches to C2 capability governance.

**Topic 5: C2 and Human AI/Autonomy Teaming**

C2 is a prime example of a socio-technical system i.e. one which has both human individual and organizational components and technical ones, which interact with each other in often unpredictable and emergent ways. This has generated some substantial challenges which have arguably still not been fully addressed. At the same time, the capabilities and sophistication of the technical components has continued to develop apace, most latterly with the recent re-emergence of AI and machine learning following previous generations of similar work in the 1980s. Somewhat paradoxically this has further increased the challenge of developing C2 systems with both human and technical components. Papers are therefore invited on this topic, i.e. approaches being explored either within C2, or sufficiently similar domains, which demonstrate how to more effectively develop systems that combine the strengths of both human and sophisticated technical (automation, AI and semi-autonomous systems) components. Of particular interest are explorations of the challenges associated with (a) organizing, orchestrating, and leveraging a variety of teams that include both humans and non-human intelligent entities and systems (b) increasingly sophisticated autonomous systems which effectively replace team members or commander, and the potential psychological-, social- and organizational impacts of this.
**Topic 6: Experimentation, Analysis, Assessment and Metrics**

Of long-standing difficulty has been the topic of developing effective and practical means of experimenting, analyzing and evaluating current and proposed future C2 capability. Whilst this previously led to the development of a number of Codes of Best Practice, there is considerable room for improvement, particularly based on continued experience and practice. Papers are thus invited which provide new insights into the design, conduct, and analysis of experiments related to any aspect of command and control. Exemplar topics for C2-related experimentation include: new classes of simulation to aid understanding and planning in tomorrow’s more diverse multidimensional operating contexts, evaluation of new socio-technical concepts, shared awareness and understanding, decision-making, planning, and execution in more complex and dynamic settings, longitudinal studies and capability maturity evaluations.

**Topic 7: Other C2 Related Research and Analysis**

This ‘topic’ should be used by authors who do not feel that their submission fits neatly into one of the above topics. The Symposium, Program, and Track Chairs will assign it to appropriate reviewers.

Please also note that there are effectively a number of long-standing but cross-cutting themes that will exist this year as they have in prior ones. Hence, related to the topics above papers may include mixtures of:

- C2 Concepts
- Theoretical Propositions and Insights
- Models – conceptual, analytic and computational
- Observations and reflections based on current practice
- Longitudinal studies and Historical analyses
Submission, Review and Acceptance Process

*Please note: All submissions will be reviewed and feedback provided on an ongoing basis. Early submissions are encouraged.*

Thank you for your interest in contributing to the 25th ICCRTS. If accepted and presented at the 25th ICCRTS, your professional paper will be posted on the International C2 Institute’s C2 and Cyber Research Portal (www.internationalc2institute.org) where ICCRTS archives can also be found.

Submission Platform

As in previous years, ICCRTS will continue to use the online service EasyChair to manage all submissions. Authors therefore need to first create a free EasyChair account and will then be directed to the paper submissions page.

EasyChair sign up and abstract submission instructions can be on the IC2I Website (www.internationalc2institute.org) by going to 25th ICCRTS Information Central

If you have any problems, please contact us at: info@internationalc2institute.org  The link to the 25th ICCRTS (2020) section of EasyChair is:

https://easychair.org/conferences/?conf=25thiccrts

Paper Types

ICCRTS welcome two different types of paper.

- Full paper – for example, reporting on initial or mid-term findings or final conclusions of ongoing research activities.
- Concept paper – papers discussing a new idea, insight and/or conjecture which is a potential topic for future research and has little or no supporting evidence at this stage.

Key Dates

Key dates are the same for both Technical and Concept Papers. Please try to avoid waiting until the last possible day to submit. Early submissions are encouraged and will receive early feedback.

* Last date to submit Paper Abstract - 15 April 2020
* Feedback on abstracts to the provided by 8 May 2020
* Last date for Paper submissions – 30 June 2020
* Feedback / decision on submissions to be provided by – 31 July 2020
* Last date for Final submissions - 7 August 2020
* Decisions, if not provided previously, will be provided by 5 September 2020
* Last date to submit Presentations – 18 October 2020
Review Criteria

The review criteria differ for Technical and Concept Papers.

Technical Paper Acceptance Criteria

The following criteria will be used by track chairs, peer reviewers, and symposium staff in their review process:

- The paper is sufficiently aligned with the theme and one or more topics of the Symposium.
- The paper is intellectually stimulating.
- The literature review is adequate/appropriate.
- The research design is adequate/appropriate.
- The data analysis is adequate/appropriate.
- The conclusions are reasonable and follow from any evidence provided.
- The paper advances the state of knowledge for C2.
- The paper is logical and consistent.
- The paper’s argument is persuasive.
- The writing is clear and readable.

Concept Paper Acceptance Criteria

The following criteria will be used by track chairs, peer reviewers, and symposium staff in their review process:

- The paper is of the appropriate type: i.e. clearly putting forward a new idea or concept, and is no more than seven pages in length.
- The paper is sufficiently aligned with the theme and one or more topics of the Symposium.
- The paper is intellectually stimulating.
- The arguments are reasonable.
- The writing is clear and readable.

Technical or Concepts Papers will not be accepted if:

- Topics stray from the conceptual focus of the Symposium.
- Attempts are made to promote or sell specific goods and/or services.
- Claims are unsubstantiated or facts are inaccurate.
- Scientific merit is lacking.
- Writing/explanations are poor.
Submission Process

All Paper submissions require the submission of an abstract.

Step 1: Identify the main topic of your paper. If it does not neatly fit into one of the topics in the Call for Papers, pick the topic that you feel is the best fit.

Step 2: Provide information about all authors (affiliations and complete addresses) and identify the corresponding author that we will use as the point of contact for all correspondence.

Step 3: The title and abstract of your paper should be entered as plain text and three keywords for the abstract must be provided. Abstracts should be no longer than 250 words.

Step 4: If you want to submit the full paper early, you can do so by uploading it via the “Uploads” section of the EasyChair website.

Step 5: If, after a review of your abstract (see acceptance criteria below), it is determined that your paper is appropriate for ICCRTS, you will be invited to submit a draft of the full paper for peer review. Invitations may also include suggestions that are designed to improve your paper and increase the probability that it will be accepted.

Step 6: Submit a draft paper for peer review. Please provide a cover sheet with your paper. This sheet should contain the name of the symposium, the topic of your paper, the title of your submission and author(s) information (affiliations and complete addresses). Please refrain from using ALL CAPS. If your paper has multiple authors, please list the affiliation for each author separately with their name.

Open the paper beginning with an abstract paragraph. Abstracts should be no longer than 250 words. If this abstract is not the same as the one provided during the abstract submission step, please update the plain text abstract window on the EasyChair website accordingly.

Only PDF format will be accepted. Paper page limit is 7 pages for concept papers and 20 pages for full papers (not including appendices, endnotes, or references). There is no fixed template for the paper; however you must ensure that all text is legible.

When reporting any set of statistical results, make sure that any data used are fully reported (central tendency, distribution, number of cases in the analysis, confidence intervals, etc.). These may be presented in the body of the paper, or in an appendix.

When reporting experimental results, you must provide sufficient information to permit the experiment to be repeated, as per accepted scientific method. This means providing an overview of the experimental design (within-subject, between-subject, Latin square, etc.), describing statistical processing methods used (ANOVA, Regression Analysis, etc.), the measure of statistical validity for any conclusions you draw (in the body of the paper), and the implications of your conclusions. Any statement on statistical validity must be contained in the body of the paper.
References can be acknowledged as footnotes throughout the text, or as a list at the end of your document.

**Step 7:** You will receive peer review feedback on your paper (see Technical Paper Acceptance Criteria below). At this time, your paper will be Accepted with or without suggestions for improvement (go to Step 10; Conditionally Accepted provided you revised in accordance with reviewer feedback (go to Step 8); Accepted as a Concept Paper (go to Step 10); or Rejected.

**Step 8:** For Conditionally Accepted Papers, submit a revised paper that incorporates reviewers’ feedback.

**Step 9:** You will receive peer review feedback on your revised paper and whether or not the paper is accepted.

**Step 10:** Provide your presentation slides directly to info@internationalc2institue.org AND to the appropriate Track Chair.

### Public Release of the Information

The ICCRTS is an open, unclassified, international meeting with many nations present. Authors are responsible for ensuring that papers are unclassified for public release and should not present sensitive material. Papers and presentation material presented at the conference will be posted to the IC2I? site for public use. For this reason, proprietary information should be avoided in all ICCRTS submissions: abstracts, papers, and presentations. All ICCRTS papers and presentations must be unclassified, and any potentially sensitive material removed. Multiple versions will not be accepted.

### Copyright

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### Inquiries

Please continue to monitor the conference website at: www.internationalc2institute.org for updates and the latest information. If you have any questions, please contact us at: info@internationalc2institute.org