When we attempt to design and engineer a novel system, which aspects of the system's complexity are most significant for the project's success or failure?

This survey aims to collect opinions on the significance of different factors that may contribute to the degree of challenge involved in designing and realising a novel engineered system, such as a novel air traffic management system or a novel semi-autonomous vehicle.

You have been invited to complete this survey as a member of the International Council on Systems Engineering (INCOSE).

This survey should take between 20 and 30 minutes to complete. The survey is open from 11th March 2019 to 10th June 2019. Thank you for taking the time to complete this survey. Its outputs will contribute towards a PhD in Systems Engineering being carried out at the University of Bristol as part of an Engineering and Physical Sciences Research Council (EPSRC) funded project (iCASE 16000139) entitled `Ensuring Flexible Design Strategies for Complex Systems Engineering'.

All responses to the survey will be kept anonymous. Participation is voluntary and you can withdraw at any time without giving a reason. However, since your data is submitted anonymously, it cannot be withdrawn at a later date. The anonymous data will be stored for a maximum of 10 years in keeping with EPSRC data management policies.

As a reward for completing the survey, participants can provide their email address on the final page to have a chance to win a £50 Amazon voucher (email addresses will be stored on a password protected spreadsheet and will not be used for any other purpose or shared with any other individual or agency). A winner will be chosen using a random number generator. Once a winner has been selected the stored email addresses will be deleted. Responses to the survey will remain anonymous, regardless of whether you enter the prize draw or not.

If you wish to contact the survey organiser, please email: Matt.Potts@Bristol.ac.uk. This survey was approved by the University of Bristol Ethics Committee on 19th February 19 (application ID 81402).

By clicking to continue to the next section you are confirming that you understand that you have read and understand the information presented above. Please click to continue to the next section if you fully and freely consent to participation in this survey.

*Required

1. **I hereby fully and freely consent to my participation in this study** *
   Mark only one oval.

   ◯ Yes
   ◯ No *Start this form over.*

Instructions

Instructions

We would like you to imagine the following scenario and keep it in mind as you complete the survey.

We are interested in the challenges facing systems engineers as they evaluate system architectures, designs, and implementations; where uncertainty, unintended consequences and conflicting world views can make successfully realising the target system challenging to varying degrees.

Please place yourself in the shoes of someone working for an organisation that designs, develops and delivers novel systems that are in some sense complex, i.e., these engineered systems may involve many inter-operating parts, may comprise several interacting sub-systems, may deliver a range of functionality, may operate in a time-sensitive or safety-critical manner, may interface with a complicated environment, may be spatially extended, networked, or highly structured, and may operate over significantly extended time scales.

Examples might include software systems, transport systems, military installations, extended enterprises, communications systems, infrastructure systems, or logistics operations.

For instance, consider an organisation that produces Air Traffic Management Systems that is contracted to deliver a system featuring some novel technical capabilities which will be deployed and integrated across a large geographical area that is subject to novel legal or regulatory requirements. Or consider an organisation producing Landing Gear Extension and Retraction Systems that is contracted to develop a system for a newly developed large commercial aircraft which must integrate and operate with both legacy systems and planned future designs. Finally, consider an organisation that produces Enterprise Information Systems that is contracted to provide a new Customer Resource Management system that will work across a restructured extended enterprise, incorporating new technology and processes, while maintaining and extending current functionality.

Please now picture a real system of this type in your own mind, one that is relevant to you. Perhaps it is a system that you have worked on, or have extensive knowledge of, or one that you feel comfortable talking about. Keep this same system in mind throughout the survey. Imagine that your organisation has seen an Invitation to Tender for a new version of the system that you are thinking of, a version that involves some enhanced capabilities or novel deployment challenges, or is on a larger scale than previous projects. Your organisation is working on a bid in response to this Invitation to Tender. As part of this process, you are asked to help evaluate the complexity of the proposed system and its operational environment. You have been told the aim of your evaluation is to enable your organisation to identify, and communicate, system complexity, and to guide the creation of an action plan to manage this complexity.
We have left details about the system (which we will refer to from now on as your "target system") and its context deliberately vague as we are interested in your individual perspectives and opinions on a system that is relevant to you and that you feel comfortable with.

With this scenario in mind, please now answer the following questions.

2. **Please indicate whether you have read the instructions.** *
Mark only one oval.

- ◯ No *Skip to question 2.*
- ◯ Yes

Keeping your target system in mind, please read the following descriptions and then answer the question below.

Technical Novelty: The level of technical innovation required to deliver the proposed system, the lack of similar systems already developed in the same deployment domain, the low level of reuse in the proposed system, the number of high added-value elements in the proposed system.

Structural Complexity: The number, diversity, distribution, connectivity and constraints of constituent components, subsystems, systems and operational nodes involved in the proposed system.

Functional Complexity: The number, behaviour, interdependencies and synchronisation of functions and functional chains involved in the proposed system, including data types, processing and memory constraints and algorithms.

Behavioural Complexity: The degree of challenge involved in defining and predicting the behavioural modes, functions, states, performance and mission properties of the proposed system, including its degree of autonomy and the impact of the environment.

Development Complexity: The degree of challenge involved in developing the proposed system throughout its lifecycle, including the amount and availability of required resources, the interlacing of design and development programmes, the complexity of system requirements, and the maturity of technology, regulations, standards, processes and methodologies.

Organisational Complexity: The number, diversity, level of support, degree of involvement and communication and coordination challenges associated with internal and external system stakeholders.

3. **To what extent are these aspects important when evaluating system complexity?** *
Mark only one oval per row.

	Not At All Important	Slightly Important	Somewhat Important	Moderately Important	Extremely Important
Development Complexity					
Structural Complexity					
Organisational Complexity					
Behavioural Complexity					
Technical Novelty					
Functional Complexity					

4. **What other aspects are important to you when evaluating system complexity?** *

To what extent has your work tended to involve evaluating or considering these aspects of a proposed or realised system?

(The same six aspects are re-described here.)

Technical Novelty: The level of technical innovation required to deliver the proposed system, the lack of similar systems already developed in the same deployment domain, the low level of reuse in the proposed system, the number of high added-value elements in the proposed system.

Structural Complexity: The number, diversity, distribution, connectivity and constraints of constituent components, subsystems, systems and operational nodes involved in the proposed system.

Functional Complexity: The number, behaviour, interdependencies and synchronisation of functions and functional chains involved in the proposed system, including data types, processing and memory constraints and algorithms.

Behavioural Complexity: The degree of challenge involved in defining and predicting the behavioural modes, functions, states, performance and mission properties of the proposed system, including its degree of autonomy and the impact of the environment.

Development Complexity: The degree of challenge involved in developing the proposed system throughout its lifecycle, including the amount and availability of required resources, the interlacing of design and development programmes, the complexity of system requirements, and the maturity of technology, regulations, standards, processes and methodologies.

Organisational Complexity: The number, diversity, level of support, degree of involvement and communication and coordination challenges associated with internal and external system stakeholders.

5. **To what extent do you have experience evaluating the following aspects?** *
   Mark only one oval per row.

	Not At All Experienced	Slightly Experienced	Somewhat Experienced	Moderately Experienced	Extremely Experienced
Organisational Complexity					
Functional Complexity					
Development Complexity					
Technical Novelty					
Structural Complexity					
Behavioural Complexity					

6. **When evaluating system complexity, what other aspects do you have experience with?** *

Introduction to Pairwise Comparisons

You will now be asked to make pairwise comparisons between these aspects of a proposed or realised system.

In each comparison, you will be presented with two aspects, A and B, and asked which, if any, is more important and whether the difference in importance is slight or significant.

Remember: Please keep your target system in mind when answering these questions.

Pairwise Comparisons

7. **Which of the following is more important when evaluating system complexity, A or B? A: The number, diversity, distribution, connectivity and constraints of constituent components, subsystems, systems and operational nodes involved in the proposed system. (Structural Complexity). B: The degree of challenge involved in developing the proposed system throughout its lifecycle, including the amount and availability of required resources, the interlacing of design and development programmes, the complexity of system requirements, and the maturity of technology, regulations, standards, processes and methodologies. (Development Complexity).** *
   Mark only one oval.

   - They are equally unimportant
   - A is much more important than B
   - A is slightly more important than B
   - They are equally important
   - B is slightly more important than A
   - B is much more important than A

8. **Which of the following is more important when evaluating system complexity, A or B? A: The number, behaviour, interdependencies and synchronisation of functions and functional chains involved in the proposed system, including data types, processing and memory constraints and algorithms. (Functional Complexity). B: The degree of challenge involved in defining and predicting the behavioural modes, functions, states, performance and mission properties of the proposed system, including its degree of autonomy and the impact of the environment. (Behavioural Complexity).** *

   Mark only one oval.

   - They are equally unimportant
   - A is much more important than B
   - A is slightly more important than B
   - They are equally important
   - B is slightly more important than A
   - B is much more important than A

9. **Which of the following is more important when evaluating system complexity, A or B? A: The number, diversity, level of support, degree of involvement and communication and coordination challenges associated with internal and external system stakeholders. (Organisational Complexity). B: The level of technical innovation required to deliver the proposed system, the lack of similar systems already developed in the same deployment domain, the low level of reuse in the proposed system, the number of high added-value elements in the proposed system.(Technical Novelty).** *

   Mark only one oval.

   - They are equally unimportant
   - A is much more important than B
   - A is slightly more important than B
   - They are equally important
   - B is slightly more important than A
   - B is much more important than A

10. **Which of the following is more important when evaluating system complexity, A or B? A: The number, behaviour, interdependencies and synchronisation of functions and functional chains involved in the proposed system, including data types, processing and memory constraints and algorithms. (Functional Complexity). B: The level of technical innovation required to deliver the proposed system, the lack of similar systems already developed in the same deployment domain, the low level of reuse in the proposed system, the number of high added-value elements in the proposed system.(Technical Novelty).** *

    Mark only one oval.

    - They are equally unimportant
    - A is much more important than B
    - A is slightly more important than B
    - They are equally important
    - B is slightly more important than A
    - B is much more important than A

11. **Which of the following is more important when evaluating system complexity, A or B? A: The number, behaviour, interdependencies and synchronisation of functions and functional chains involved in the proposed system, including data types, processing and memory constraints and algorithms. (Functional Complexity). B: The number, diversity, distribution, connectivity and constraints of constituent components, subsystems, systems and operational nodes involved in the proposed system. (Structural Complexity).** *

Mark only one oval.

- They are equally unimportant
- A is much more important than B
- A is slightly more important than B
- They are equally important
- B is slightly more important than A
- B is much more important than A

12. **Which of the following is more important when evaluating system complexity, A or B? A: The degree of challenge involved in defining and predicting the behavioural modes, functions, states, performance and mission properties of the proposed system, including its degree of autonomy and the impact of the environment.(Behavioural Complexity). B: The number, diversity, level of support, degree of involvement and communication and coordination challenges associated with internal and external system stakeholders. (Organisational Complexity).** *

Mark only one oval.

- They are equally unimportant
- A is much more important than B
- A is slightly more important than B
- They are equally important
- B is slightly more important than A
- B is much more important than A

13. **Which of the following is more important when evaluating system complexity, A or B? A: The degree of challenge involved in developing the proposed system throughout its lifecycle, including the amount and availability of required resources, the interlacing of design and development programmes, the complexity of system requirements, and the maturity of technology, regulations, standards, processes and methodologies. (Development Complexity). B: The degree of challenge involved in defining and predicting the behavioural modes, functions, states, performance and mission properties of the proposed system, including its degree of autonomy and the impact of the environment. (Behavioural Complexity).** *

Mark only one oval.

- They are equally unimportant
- A is much more important than B
- A is slightly more important than B
- They are equally important
- B is slightly more important than A
- B is much more important than A

14. **Which of the following is more important when evaluating system complexity, A or B? A: The number, diversity, level of support, degree of involvement and communication and coordination challenges associated with internal and external system stakeholders (Organisational Complexity). B: The degree of challenge involved in developing the proposed system throughout its lifecycle, including the amount and availability of required resources, the interlacing of design and development programmes, the complexity of system requirements, and the maturity of technology, regulations, standards, processes and methodologies. (Development Complexity).** *

Mark only one oval.

- They are equally unimportant
- A is much more important than B
- A is slightly more important than B
- They are equally important
- B is slightly more important than A
- B is much more important than A

15. **Which of the following is more important when evaluating system complexity, A or B? A: The number, diversity, distribution, connectivity and constraints of constituent components, subsystems, systems and operational nodes involved in the proposed system. (Structural Complexity). B: The number, diversity, level of support, degree of involvement and communication and coordination challenges associated with internal and external system stakeholders. (Organisational Complexity).** *

Mark only one oval.

- They are equally unimportant
- A is much more important than B
- A is slightly more important than B
- They are equally important
- B is slightly more important than A
- B is much more important than A

16. **Which of the following is more important when evaluating system complexity, A or B? A: The level of technical innovation required to deliver the proposed system, the lack of similar systems already developed in the same deployment domain, the low level of reuse in the proposed system, the number of high added-value elements in the proposed system.(Technical Novelty). B: The degree of challenge involved in developing the proposed system throughout its lifecycle, including the amount and availability of required resources, the interlacing of design and development programmes, the complexity of system requirements, and the maturity of technology, regulations, standards, processes and methodologies.(Development Complexity).** *

Mark only one oval.

- They are equally unimportant
- A is much more important than B
- A is slightly more important than B
- They are equally important
- B is slightly more important than A
- B is much more important than A

17. **Which of the following is more important when evaluating system complexity, A or B? A: The number, diversity, distribution, connectivity and constraints of constituent components, subsystems, systems and operational nodes involved in the proposed system. (Structural Complexity). B: The degree of challenge involved in defining and predicting the behavioural modes, functions, states, performance and mission properties of the proposed system, including its degree of autonomy and the impact of the environment. (Behavioural Complexity).** *

Mark only one oval.

- They are equally unimportant
- A is much more important than B
- A is slightly more important than B
- They are equally important
- B is slightly more important than A
- B is much more important than A

18. **Which of the following is more important when evaluating system complexity, A or B? A: The number, behaviour, interdependencies and synchronisation of functions and functional chains involved in the proposed system, including data types, processing and memory constraints and algorithms. (Functional Complexity). B: The number, diversity, level of support, degree of involvement and communication and coordination challenges associated with internal and external system stakeholders. (Organisational Complexity).** *

Mark only one oval.

- They are equally unimportant
- A is much more important than B
- A is slightly more important than B
- They are equally important
- B is slightly more important than A
- B is much more important than A

19. **Which of the following is more important when evaluating system complexity, A or B? A: The number, behaviour, interdependencies and synchronisation of functions and functional chains involved in the proposed system, including data types, processing and memory constraints and algorithms.(Functional Complexity). B: The degree of challenge involved in developing the proposed system throughout its lifecycle, including the amount and availability of required resources, the interlacing of design and development programmes, the complexity of system requirements, and the maturity of technology, regulations, standards, processes and methodologies. (Development Complexity).** *

Mark only one oval.

- They are equally unimportant
- A is much more important than B
- A is slightly more important than B
- They are equally important
- B is slightly more important than A
- B is much more important than A

20. **Which of the following is more important when evaluating system complexity, A or B? A: The level of technical innovation required to deliver the proposed system, the lack of similar systems already developed in the same deployment domain, the low level of reuse in the proposed system, the number of high added-value elements in the proposed system. (Technical Novelty). B: The degree of challenge involved in defining and predicting the behavioural modes, functions, states, performance and mission properties of the proposed system, including its degree of autonomy and the impact of the environment. (Behavioural Complexity).** *

Mark only one oval.

- ◯ They are equally unimportant
- ◯ A is much more important than B
- ◯ A is slightly more important than B
- ◯ They are equally important
- ◯ B is slightly more important than A
- ◯ B is much more important than A

21. **Which of the following is more important when evaluating system complexity, A or B? A:The number, diversity, distribution, connectivity and constraints of constituent components, subsystems, systems and operational nodes involved in the proposed system. (Structural Complexity). B: The level of technical innovation required to deliver the proposed system, the lack of similar systems already developed in the same deployment domain, the low level of reuse in the proposed system, the number of high added-value elements in the proposed system. (Technical Novelty).** *

Mark only one oval.

- ◯ They are equally unimportant
- ◯ A is much more important than B
- ◯ A is slightly more important than B
- ◯ They are equally important
- ◯ B is slightly more important than A
- ◯ B is much more important than A

Here, we are interested in your experiences with system complexity evaluation. Please answer the following questions. Thank you for your input so far, the survey is nearly complete.

22. **Please describe your experience of complexity evaluation (for example; the extent to which this type of activity has been a part of your job, the purpose of any complexity evaluation that you have been involved in, how successful or otherwise you felt complexity evaluation was, the challenges you faced, etc,.)**

23. **How much experience do you have conducting system complexity evaluation?** *
Mark only one oval.

- Lots
- Quite A Lot
- Some
- Not A Lot
- None
- Not Sure

24. **Does your current organisation conduct system complexity evaluation?** *
Mark only one oval.

- Always
- Very Often
- Sometimes
- Rarely
- Never
- Not Sure

Your Background

25. **Please indicate your experience working in a systems engineering context.** *
Mark only one oval.

- < 5 years
- 5 - 10 years
- 10 - 15 years
- 15 - 20 years
- > 20 years
- I have not worked in a systems engineering context

26. **Which of the following best describes your current role?** *
Mark only one oval.

- Academic
- Other
- Systems Architect
- Student
- Project/Programme Manager
- Systems Engineer
- Business Analyst
- Engineering Manager

27. **Which sector are you currently predominately employed within?** *

Mark only one oval.

- Defence and Space
- Aerospace
- Communications and IT
- Research
- Academia
- Health
- Automotive
- Other

28. **Which region do you predominately work in?** *

Mark only one oval.

- North America and Canada
- South America
- Europe
- Africa
- Middle East
- Asia
- Pacific
- Other

Submission

Thank you for taking the time to complete this survey. Once you have submitted this survey you be provided an opportunity to be entered into an anonymous prize draw if you wish.

PLEASE MAKE SURE YOU HIT SUBMIT ON THIS PAGE TO COMPLETE YOUR SURVEY!

If you don't hit submit your data will not be uploaded to the server and we will not be able to use your survey contribution!

To finish the survey please now click on the submit button below.