



# Command and Control as Design

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# Outline

- The need for an ontology
- Observations leading to the conception of C2 research as one of the sciences of the artificial
- Elements of C2 as a science of the artificial
- Design logic as a tool
- Application of design logic to C2 systems and C2 as an activity
- Normative and descriptive C2 research
- Testing a theory of C2 in terms of design
- The DOODA loop as a means for integrating the functions of C2 and for illustrating the relation between the inner system of C2 to the outer system where military effects are to be achieved
- Relation between the top-down analysis from design logic to bottom-up empirical analysis from Stanton, et. al.
- Conclusions

# Need for an ontology

- Despite a growing number of studies of C2 there is little cumulative growth in our understanding of C2
- The studies are made within frameworks provided by engineering and behavioral sciences
- We need an ontological framework for C2 that allows us to translate results from different studies into common terms
- Neither engineering nor behavioral science provide such a framework
- In this paper I continue my work to provide an ontological framework based on the conception of C2 as design to provide the needed framework

# Initial observations

- All C2 is problem solving
- It is concerned with designing courses of action
- C2 is always conducted within a C2 system and it is, at least in part, shaped by that system
- The term "C2 system" should be understood as comprising the people, the organization, the methods used and the support systems employed
- Evaluation of C2 is evaluation of the C2 system not only of the commander
- The commander is both empowered and limited by his system
- C2 science is concerned with the analysis of C2 systems
- Such systems are artifacts just as C2 is an artifact and best understood in terms of the logic of design
- Hence C2 science is one of the "the sciences of the artificial" C2 systems are the result of design they are artifacts (Simon)
- C2 systems are artifacts designed to produce artifacts (COAs)

# Elements of a Science of the Artificial according to Simon

- A science of the artificial is concerned with the creation of tools that support achieving goals and with analysing behavior that is supported by tools
- These tools are not only hardware, but can be software as well
- A science of the artificial is concerned with the analysis of two systems and their interface
- The outer system (where the effects are sought)
- The inner system (the system that designs the effects)
- The interface (the means by which the effects are achieved)
- The exact system boundaries depend on the purpose of analysis (or design)

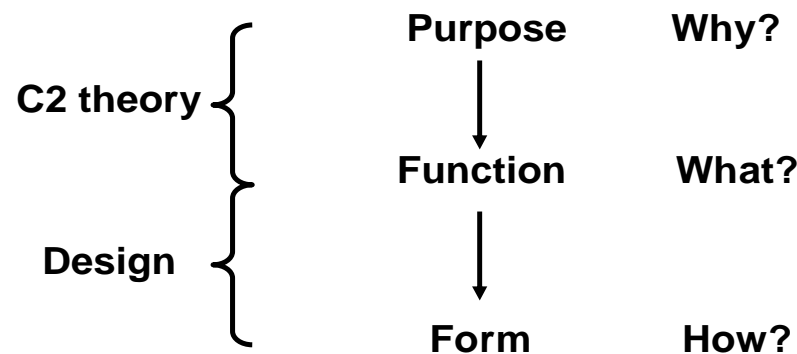
# System Boundaries depend on the purpose of the analysis

- When training the army, the inner system is the C2 system, the outer system is the army being trained, and interface is the orders produced by the C2 system
- In combat, the inner system is still the C2 system, the outer system is the enemy and the terrain and the interface consists of own forces, which are configured by the orders from the C2 system in such a way as to achieve the goals

# The problems for a science of C2 as a Science of the Artificial

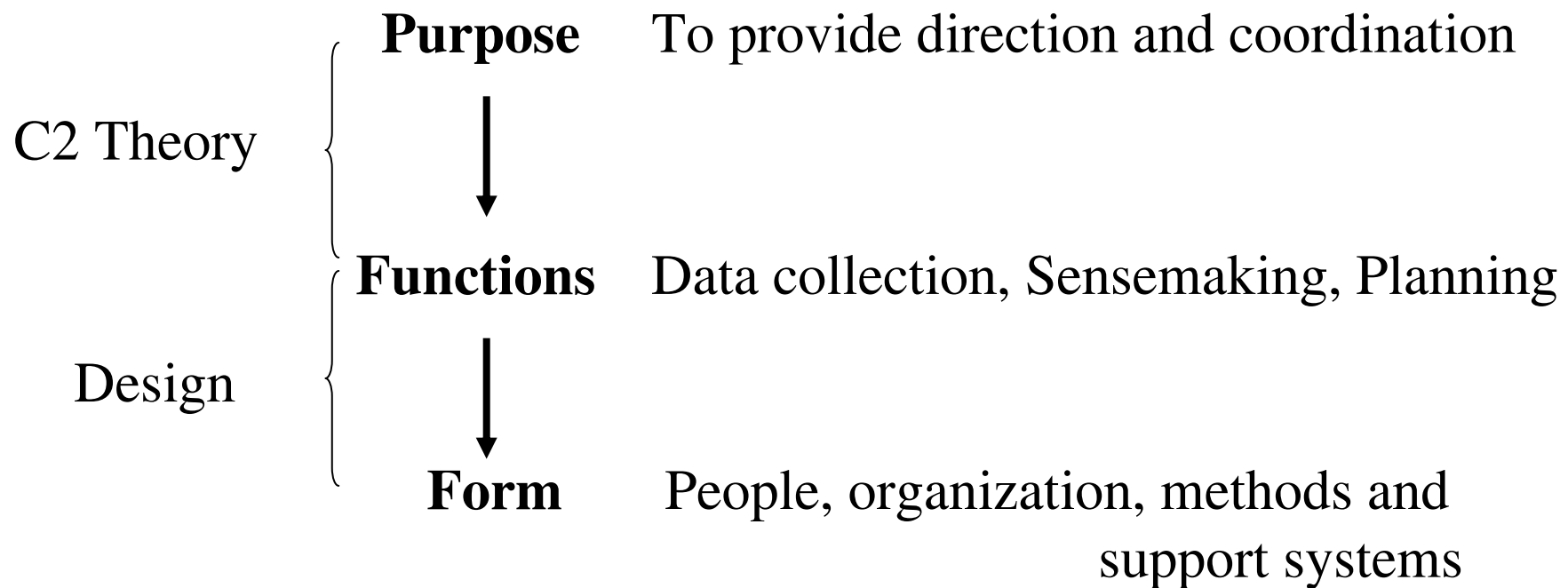
- There are at least five problems for a C2 science
  - to design effective C2 systems
  - to understand C2 systems as a result of design
  - to understand C2 as an activity that takes place within a C2 system and is shaped by that system
  - to design effective forms of C2
  - to understand the products of C2 systems in terms of design
- An effective C2 system is a system that can produce the requisite variety that achieving one's goals in the outer system requires (Ashby)
- A C2 system must be capable of creating, maintaining and updating a model of the outer system (Conant & Ashby)
- Evaluation of a C2 system is evaluating the how and to what extent to which it can do this
- This is a matter of understanding C2 as an activity and how that activity is supported (or hindered) by the C2 system

# Design logic is the principal too for understanding C2 systems

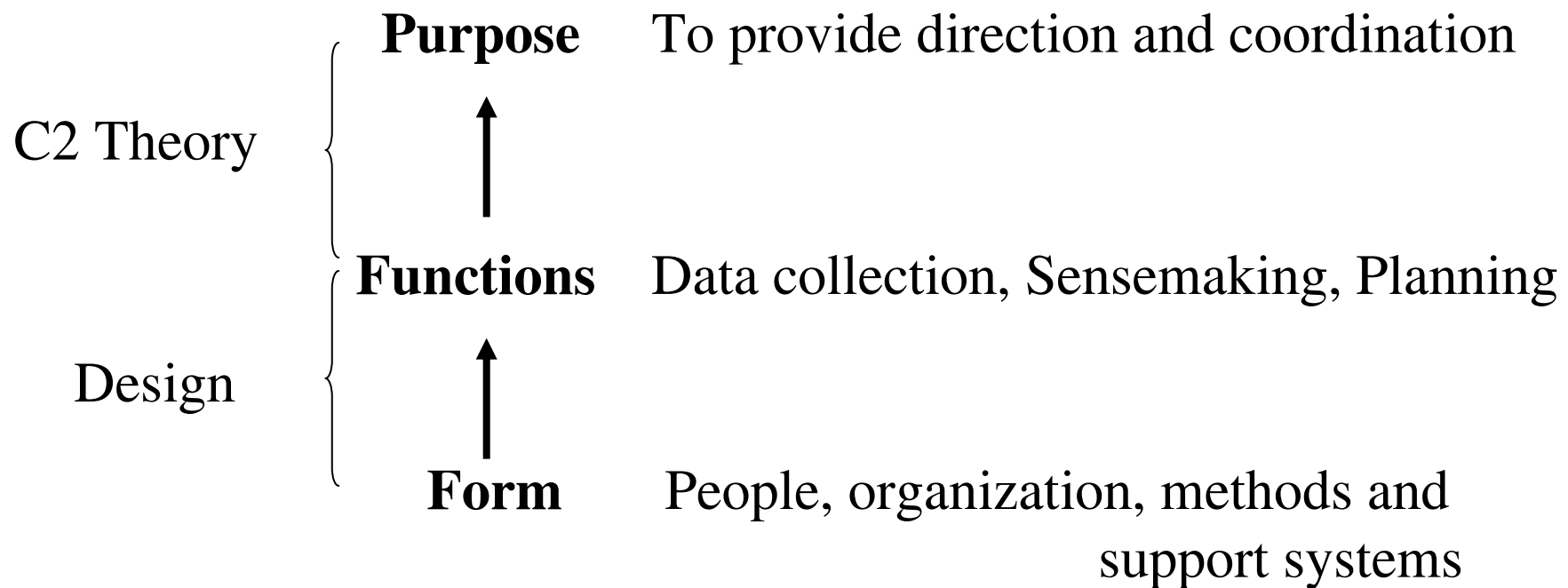




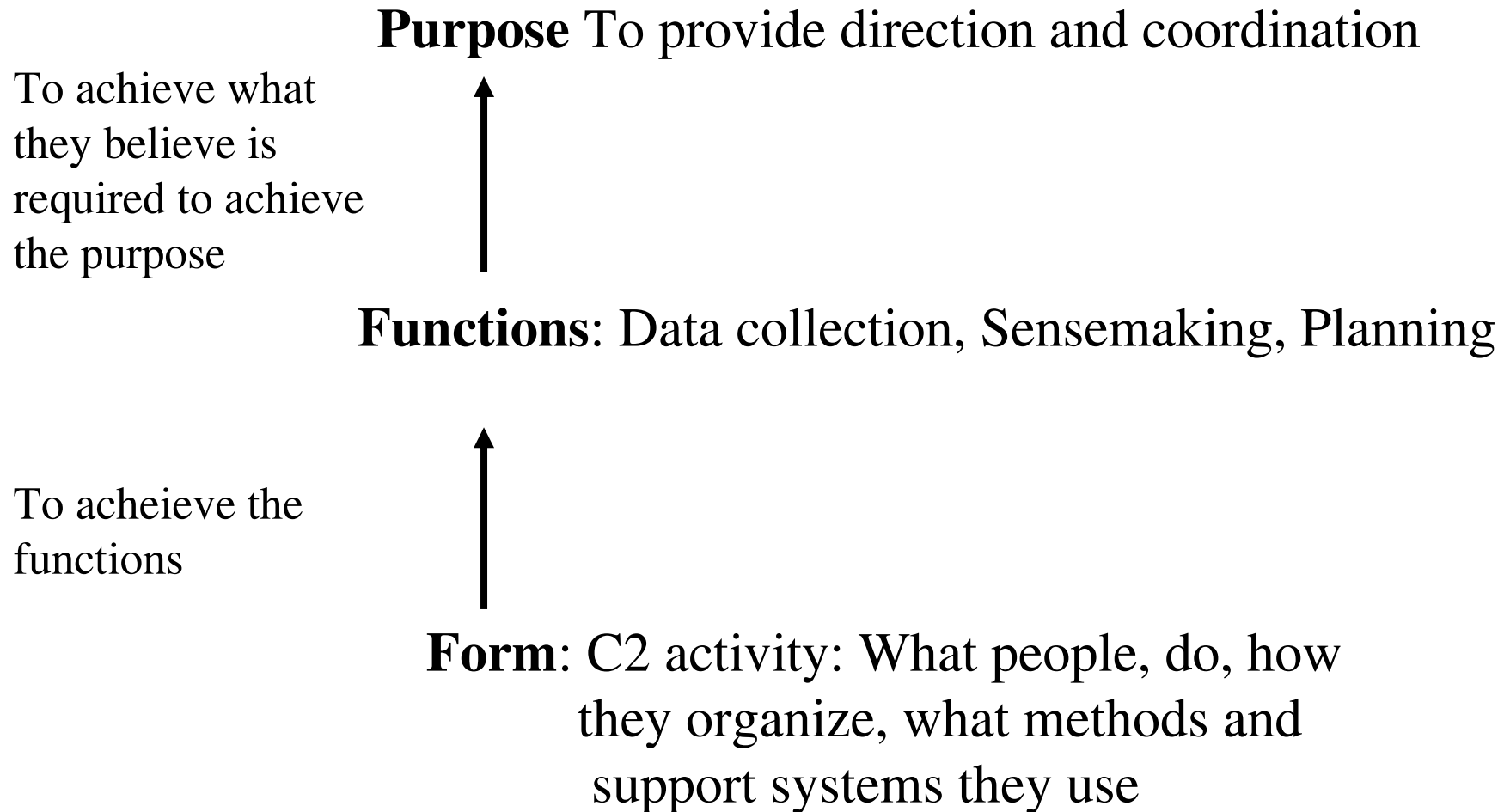
# Design of a C2 system



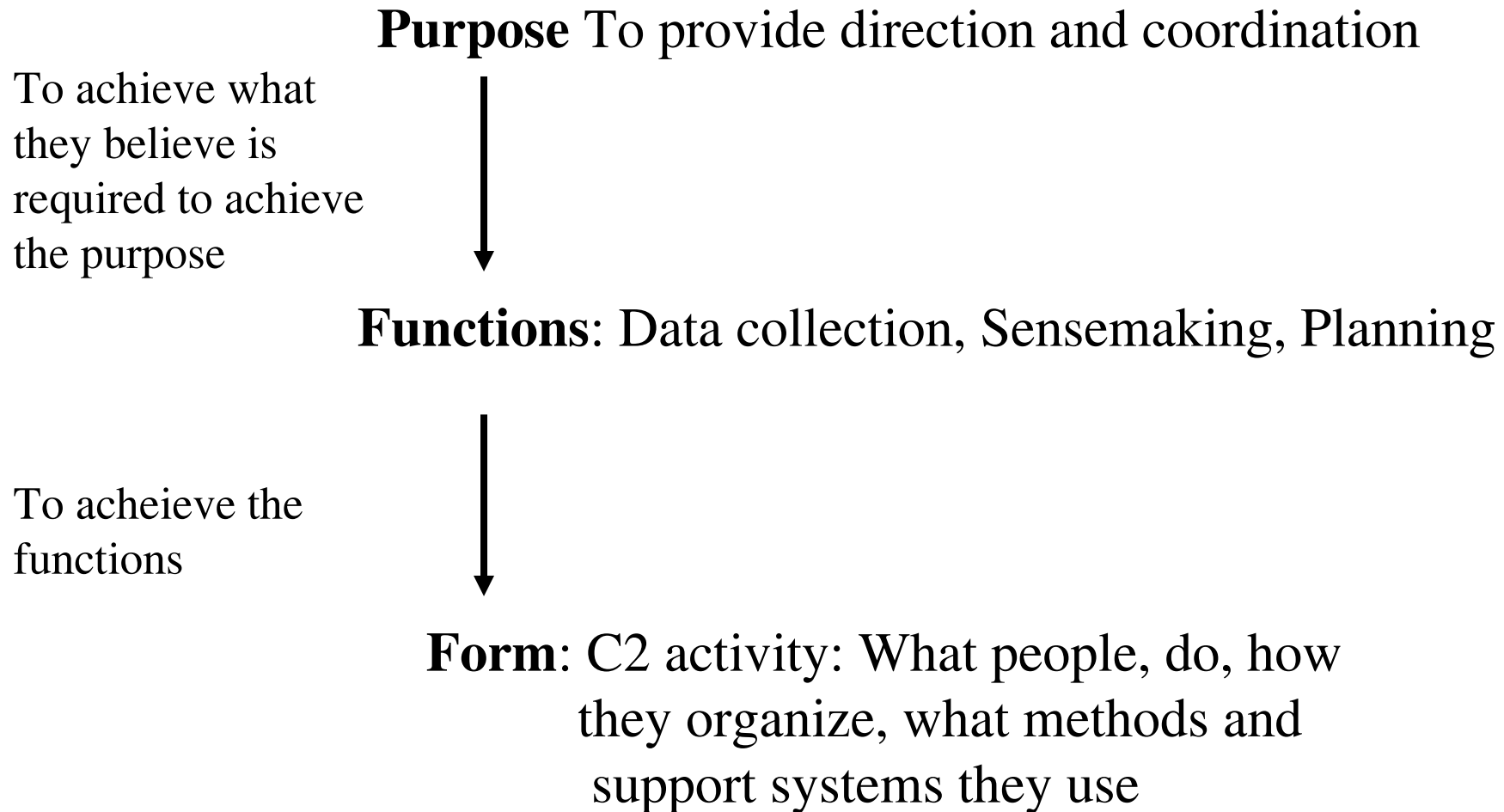
# Understanding an existing C2 system



# Analysis of C2 activity in terms of design logic



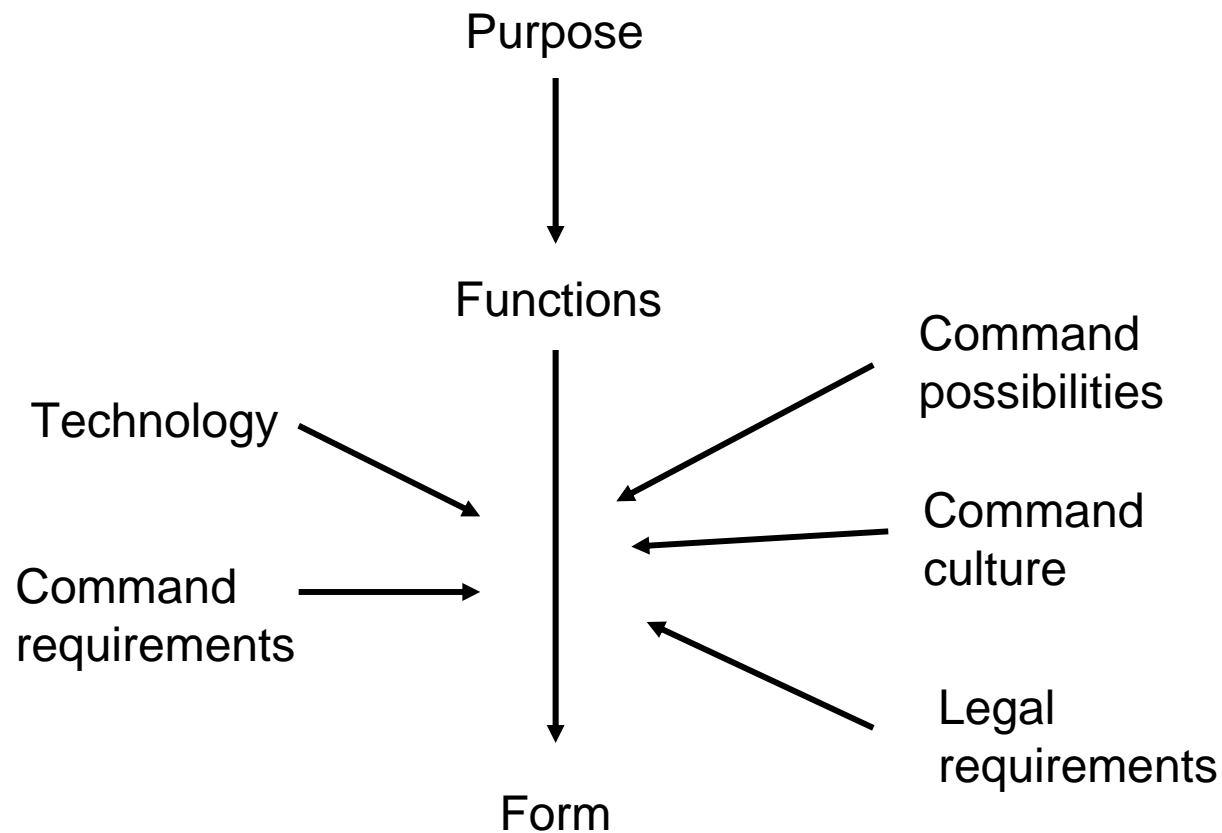
# Design of C2 activity in terms of design logic



# Normative C2 Theory is not All

- We simply do not know enough about how to design form that achieves the functions in an optimal way
- This leaves room for other factors in the design process
- Some of these are factors that must be allowed to influence form regardless of whether they contribute to achieving the functions or not, others fill in for our ignorance
- Some of these factors in the design process as discussed in last year's ICCRTS paper
  - Technology
  - Command requirements
  - Command possibilities
  - Command culture
  - Legal requirements

# From functions to form: A descriptive model of C2



# Testing a Theory of C2

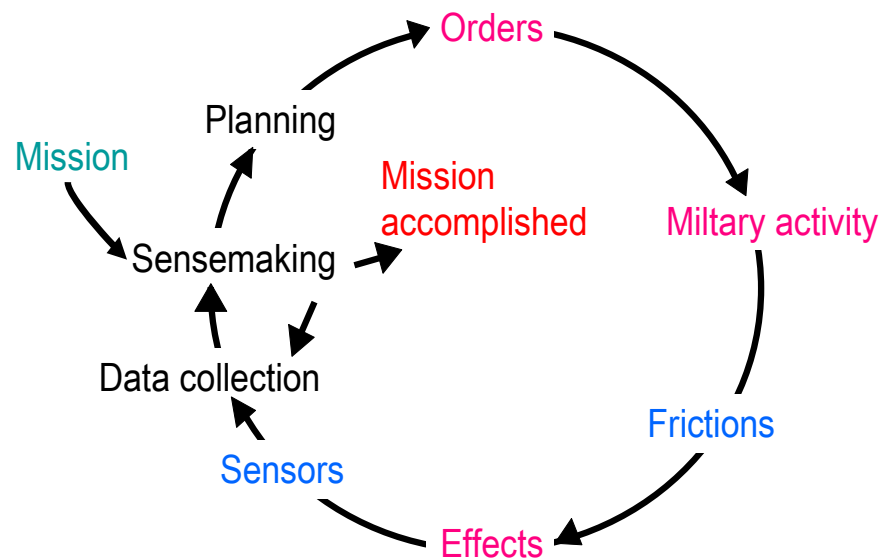
- Testing a theory of C2 is testing whether the functions proposed in theory are necessary and sufficient
- The functions are black boxes, defined in terms of input and output
- Testing the theory is thus a matter of identifying the products of the functions empirically
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- For example, testing the current theory is a matter of identifying the data collected (data collection), whether there is a decision about what is to be done (sensemaking) and a decision about how it is to be done (planning). Both the what and the how are sometimes found in the orders produced

# Putting it together: The Dynamic OODA loop

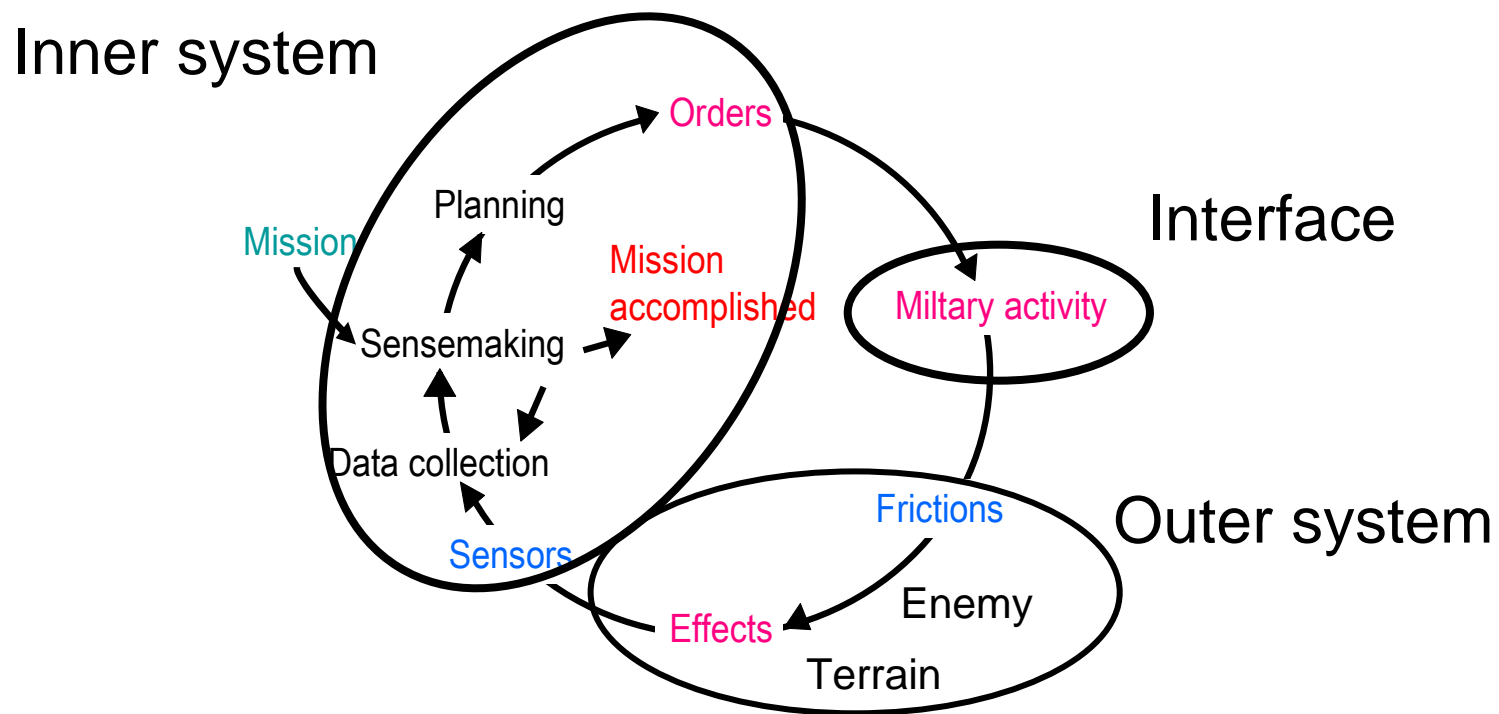
- As already mentioned, the functions are black boxes defined in terms of the input they need and their products
- They need to be put into a context that connects them in terms of input and output
- This is done in the Dynamic OODA loop, our general model of C2
- It relates the functions to each other and the inner system (The C2 system) to the outer system and the interface



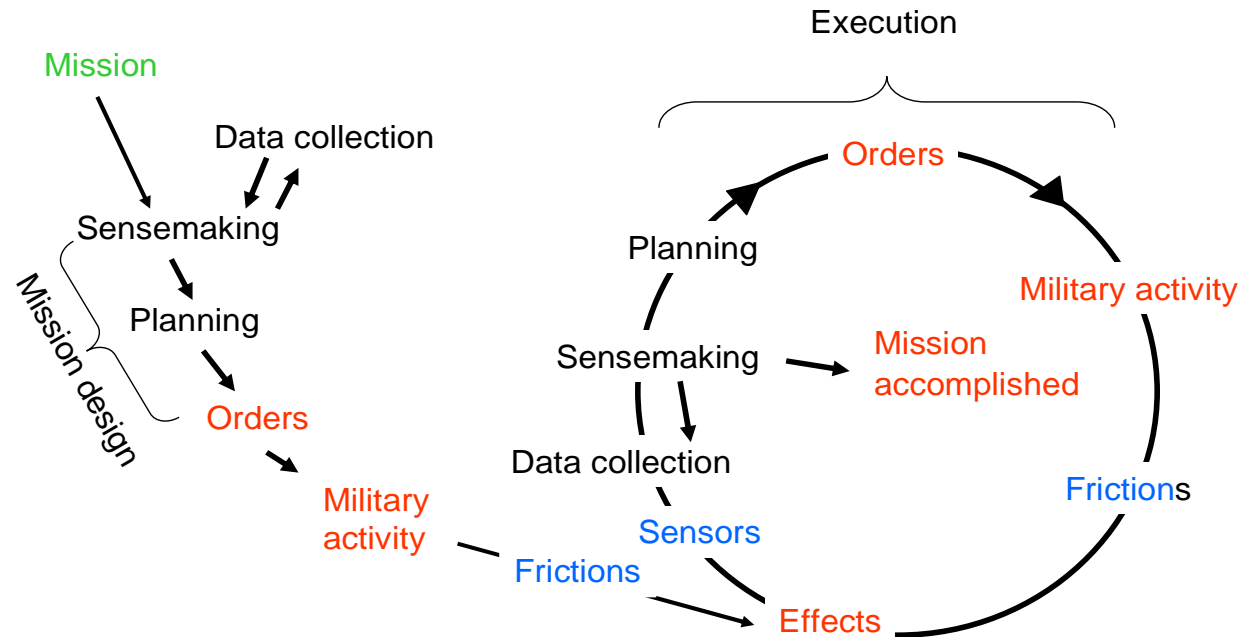
# The Dynamic OODA loop



# The inner system, the outer system and the interface in the Dynamic OODA loop

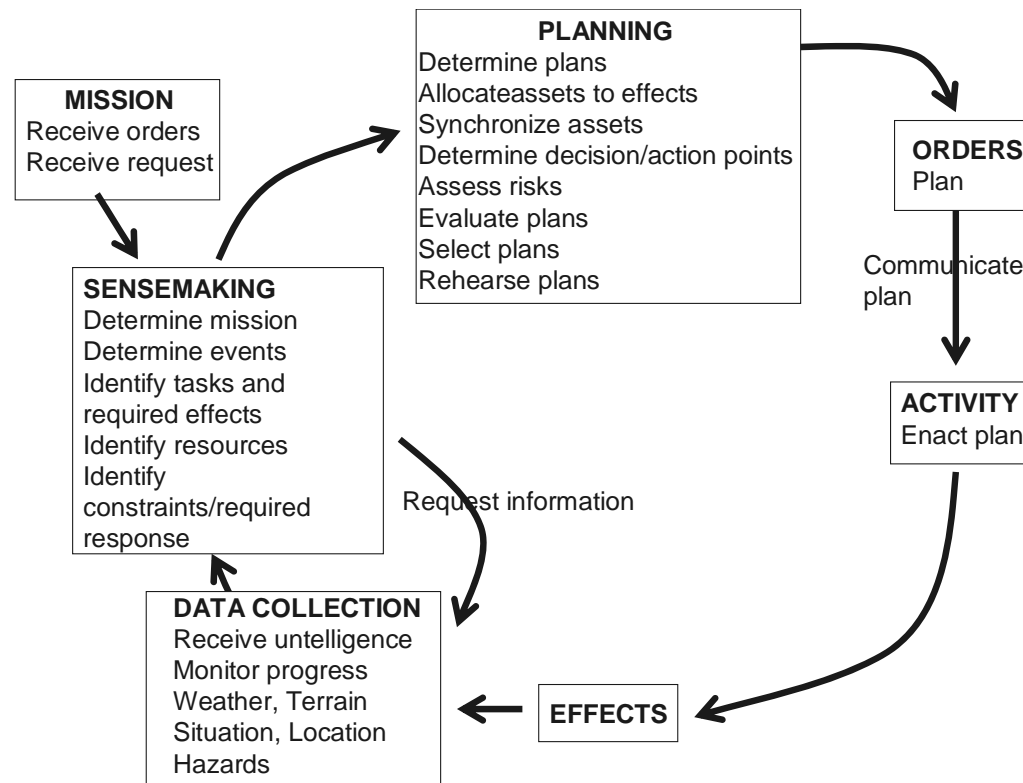


# Separation of planning and execution in DOODA-terms



# A bottom-up approach: The Stanton, Baber and Harris model in DOODA format

A model based  
on studies of C2  
in both civilian  
and military  
contexts



# Conclusions

- It is important to distinguish between the general ontological framework provided by design and the DOODA-concept which is our current theory of C2
- The conception of C2 science as design provides a useful ontological framework that can handle the understanding and design of C2 system and C2 as an activity, as well for conceptualising the product of C2
- There is a possible convergence between the top-down analysis from design and the empirical analysis bottom-up upon a limited number of general functions
- I So, to conclude I see some hope for a more integrated view of C2, based on the ontological framework of C2 research as design and as one of the sciences of the artificial