The M-OODA: A Model Incorporating Control Functions And Teamwork In The OODA Loop.

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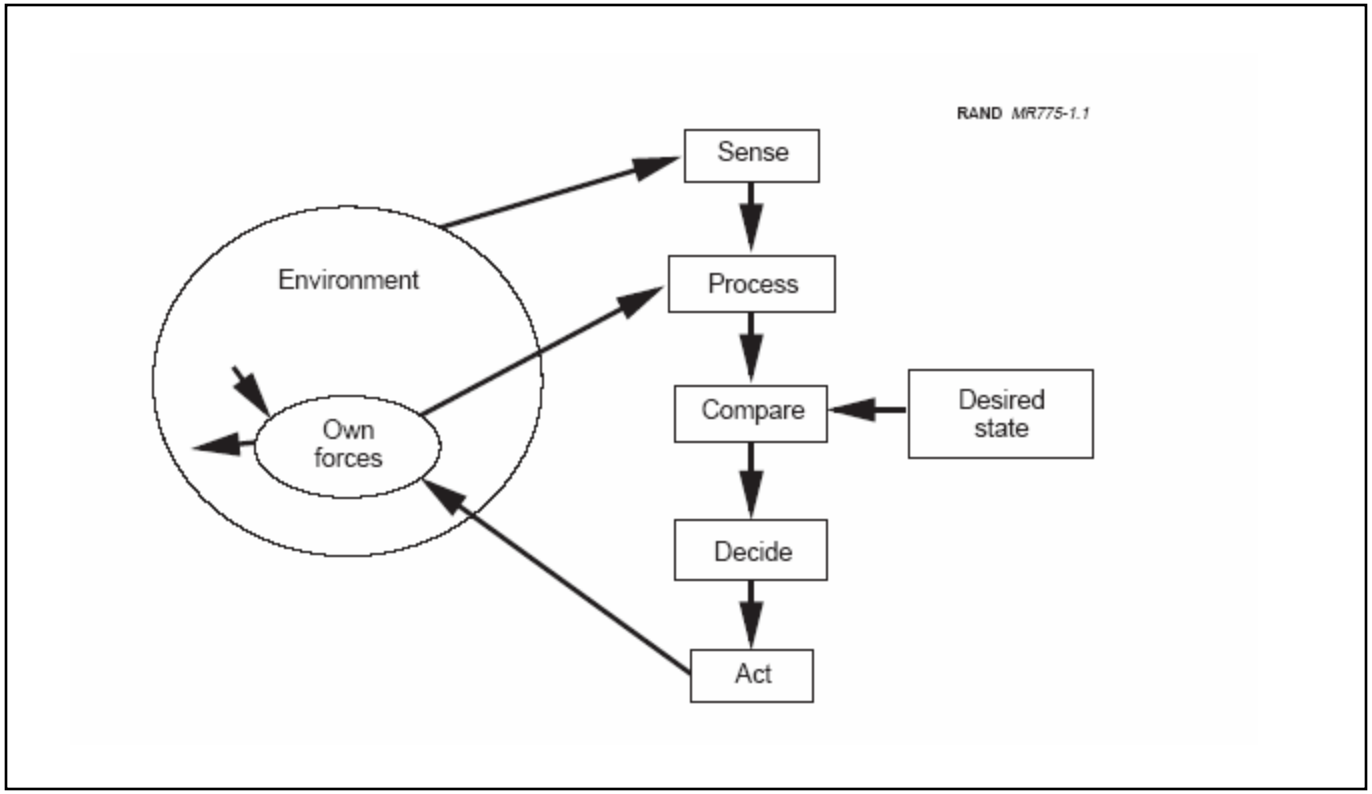
Modeling Decision Making in C2

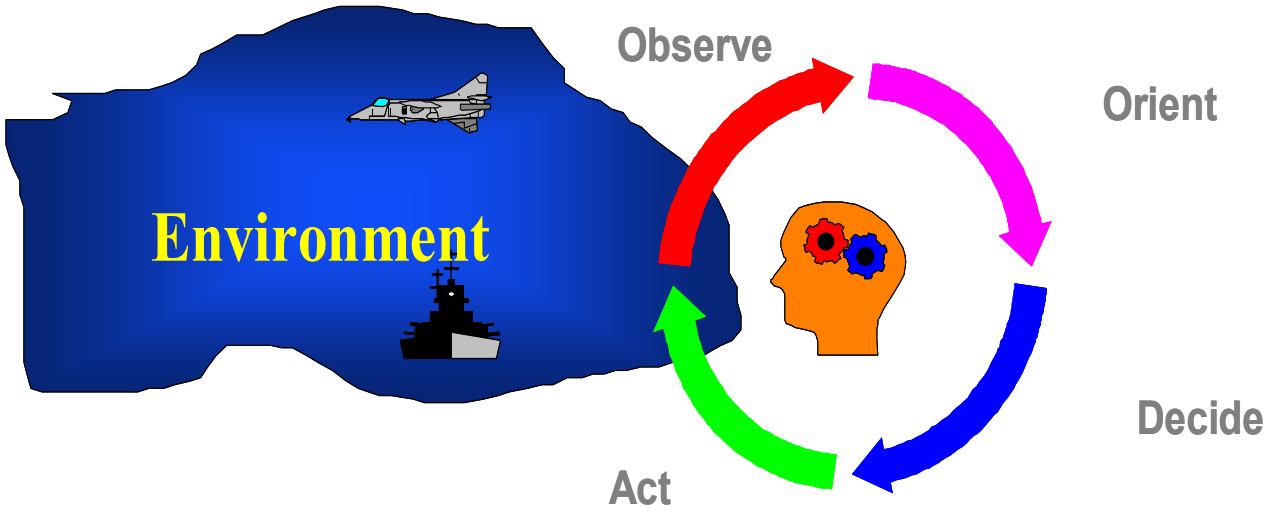
- C2 is often defined as a control task in which decision-making is continuous (Brehmer, 1982) and comprises a number of sub-tasks ranging from perception to action
- Over the last 25 years, a number of descriptive models of C2 have been proposed based on that paradigm.
- For instance, early models like Lawson's (1981) or Wohl's SHOR model (1981) describe a set of processes spanning information sensing to action implementation processes. Mayk & Rubin (1988) provide a systematic analysis of 15 different block models of C2 descriptive models.
- All these models are descriptive models that are a form of representation of a basic perception-action loop operating in an environment.

Lawson's 1981 model: An early model
(Adapted from Builder et al., 1999, RAND MR775)



Lawson, J. S., (1981). Command and Control As a Process.
IEEE Control Systems Magazine, March, pp. 5–12.

Boyd's Classical OODA Loop: The Prototypical model



- It is a very simple action cycle originating in observing the environment and terminating by acting on it.
- It has been developed in the context of command and control activities typical of military decision-making.

The OODA Loop in the US military C2 Doctrine

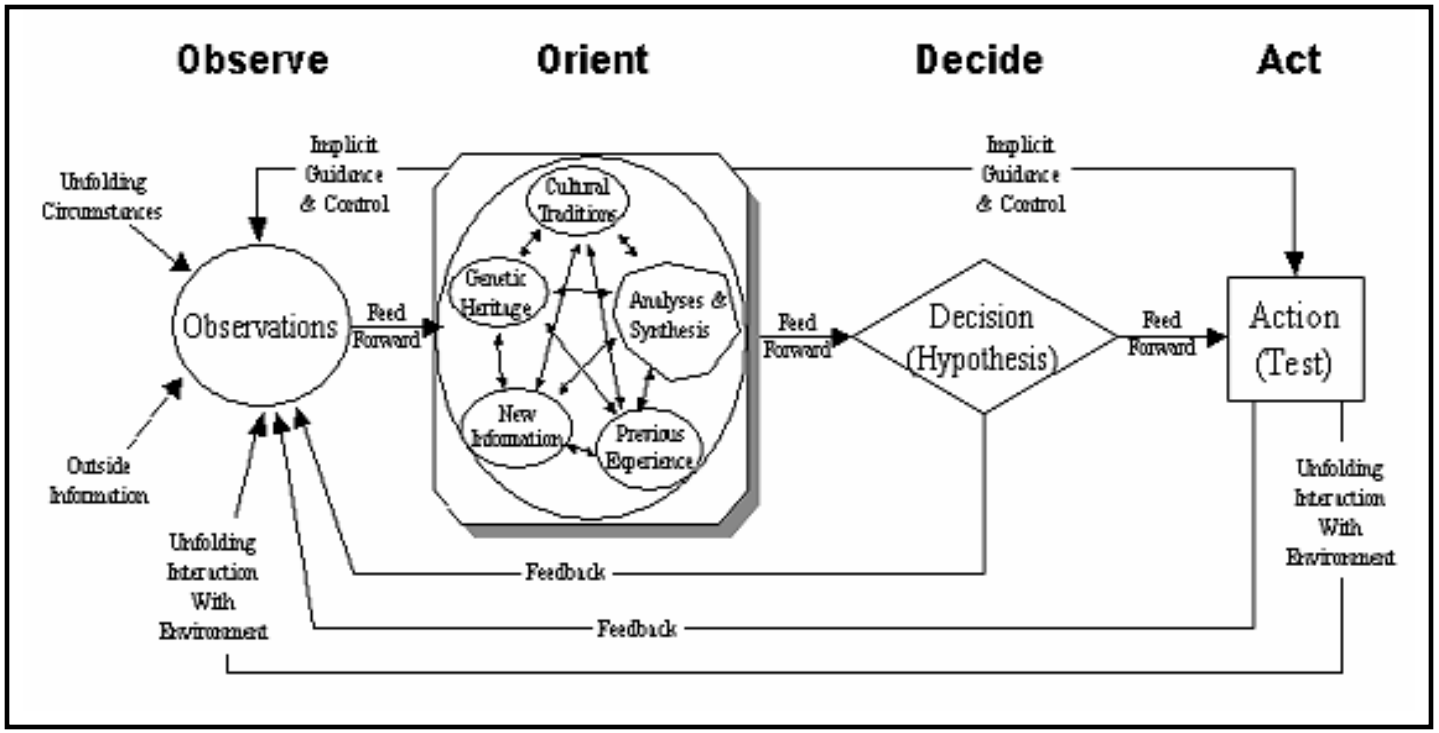
- U.S. Army Field Manual (FM 6.0, 2003) defines Control as a regulation of forces and systems to achieve mission goals in accordance with the commander's intent.
  - considers the OODA loop to be a valuable tool for illustrating a commander's decision-making processes
- In U.S. Air Force AFDD 2-8 (1999), control is defined as a set of processes for planning, directing and coordinating. In AFDD 2-5 on Information, control is defined as the processes by which commanders plan and guide operations.
  - uses the OODA loop model as the basic set of processes describing a commander's decision-making capability.
- In the U.S. Navy doctrine document (NDP 6, 1995) on naval C2, the OODA loop is given a central position as the basis for describing the Decision-Execution cycle in C2.

Limitations of the OODA LOOP

While the OODA loop is a useful high-level representation of the basic processes in C2 decision-making it is limited by three basic difficulties:

1) It has no representation of the feedback or feed-forward loops needed to effectively model dynamic decision-making.
2) It is a very high-level representation with abstract concepts that do not provide the kind of details needed for the OODA loop to be used as an analytical tool for improving decision-making.
3) It is a strict sequential model with a single entry point and a single sequence of processes that cannot adapt to different levels of expertise in decision-making and to the diverse task context existing in real tasks.

The Extended OODA loop (Fadok, Boyd & Warden, 1995)



- Explicit data feedback and feed forward loops are included
- All feedback loops only connect with the Observation process
- Factors in the Orient process are very diverse and in some cases difficult to estimate

Modifying the OODA Loop

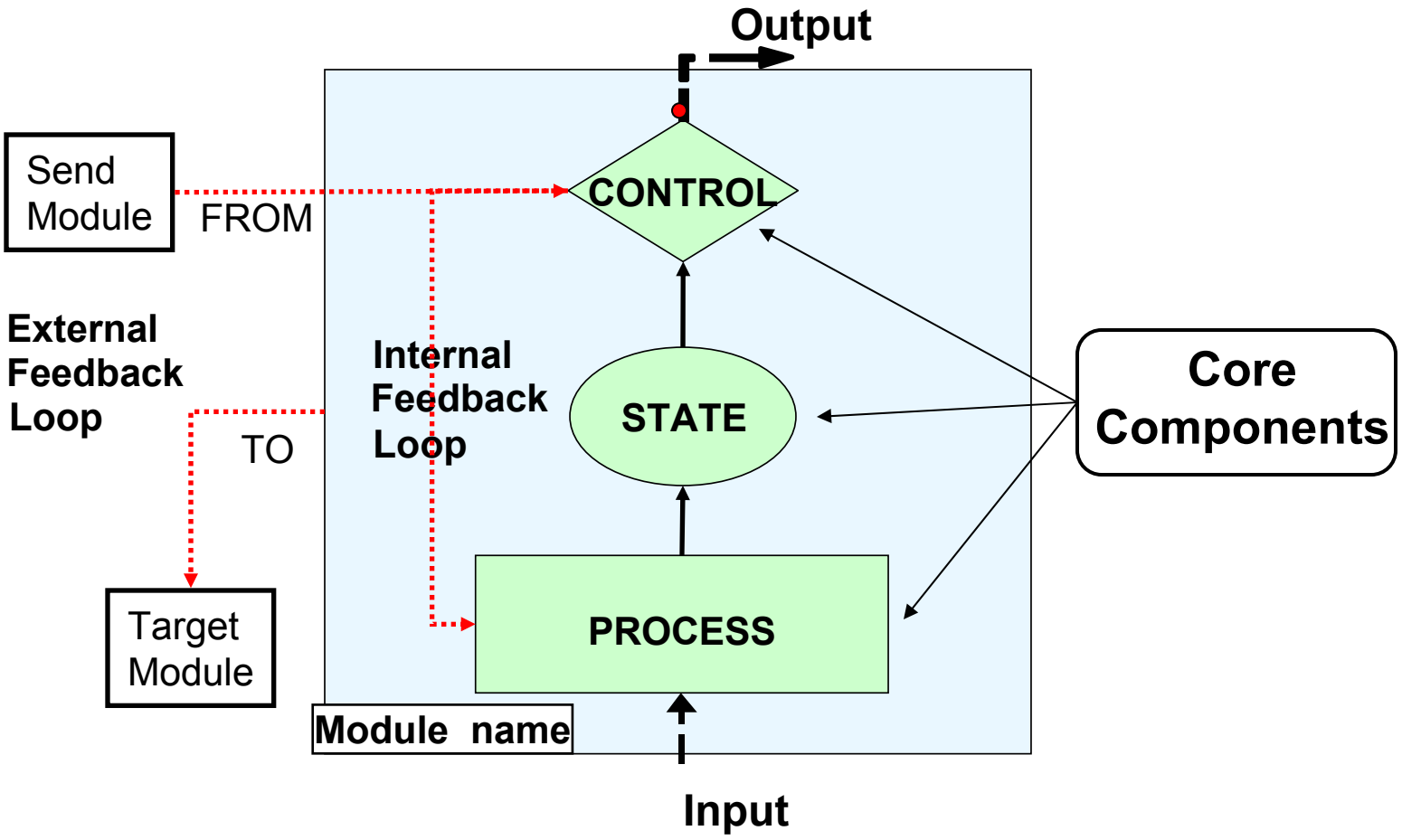
For the OODA loop to remain a useful tool in the context of the armed forces doctrine on C2, any modification has to keep explicit the high-level representation typical of the OODA loop, while accommodating dynamic and control concepts.

The Modular-OODA Loop

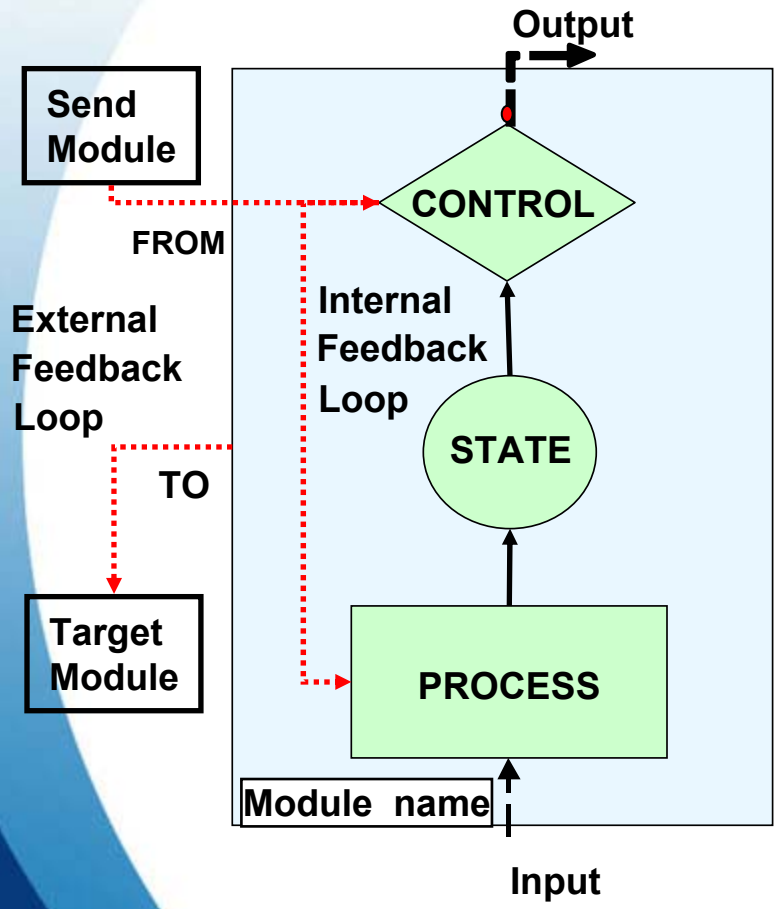
Modeling Principles

- The M-OODA modifies the OODA loop based on the following principles:
  - Adopts a **modular**, or building blocks,
  - Each process of the OODA loop is represented as a **generic module** structured around three core components: *Process, State and, Control*;
  - Incorporates **explicit control** elements:
    - **Within module feedback** loop and
    - **Between module feedback** loops for bi-directional data/information flow between modules.
- The M-OODA provides a basic architecture for modeling a variety of team decision-making with the OODA loop.

The Basic Module

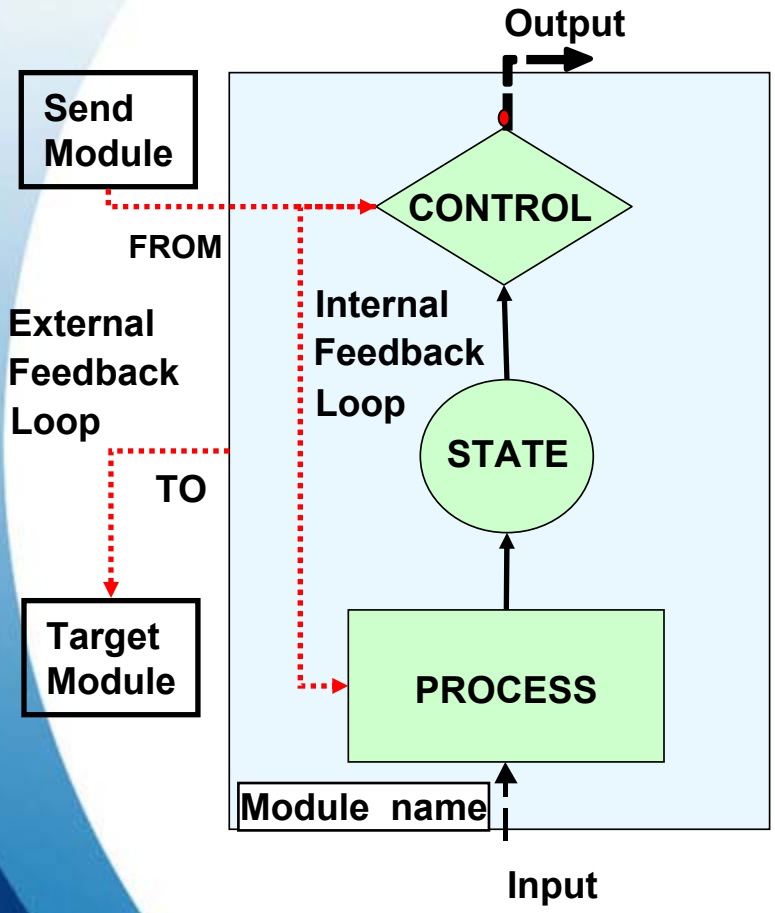


Describing the Core Components



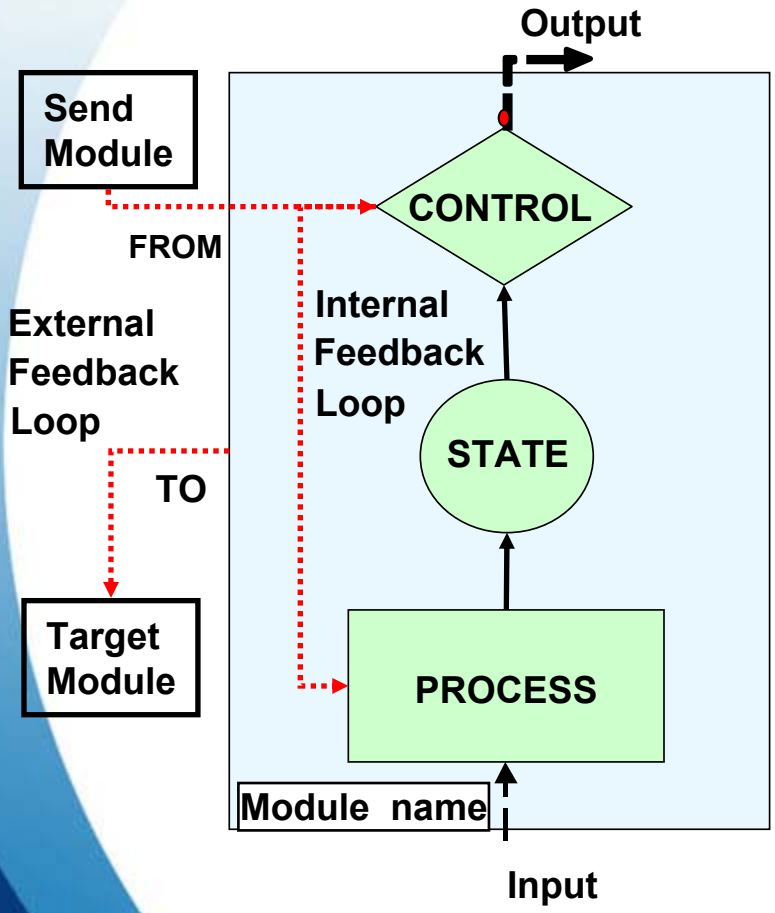
- ***Process.***
  - A goal-directed operation applied on an input.
  - Its properties depend on the nature of the module goal.
  - Generates a state in the module.
  - It can be viewed as a function including a number of processes
- ***State.***
  - structured representation
  - granularity of the aggregation in time and space determined by the processes.
- ***Control.***
  - A flow control function based on criteria like time and quality for:
    - gating the delivery of the output to other modules
    - enabling iterations of the process within the module.
  - Receives and adapt requests from, and send requests to other modules

The Input/Output components



- ***Input.***
  - Mainly outputs from other M-OODA modules.
  - Information from the environment
- ***Output.***
  - Current status of the state resulting from the process that reaches an acceptable level in the criteria-based control component.
  - The output becomes the input for a subsequent module.
- ***Module name***
  - Noun-verb describing the goal of the module

The Feedback Loop Components

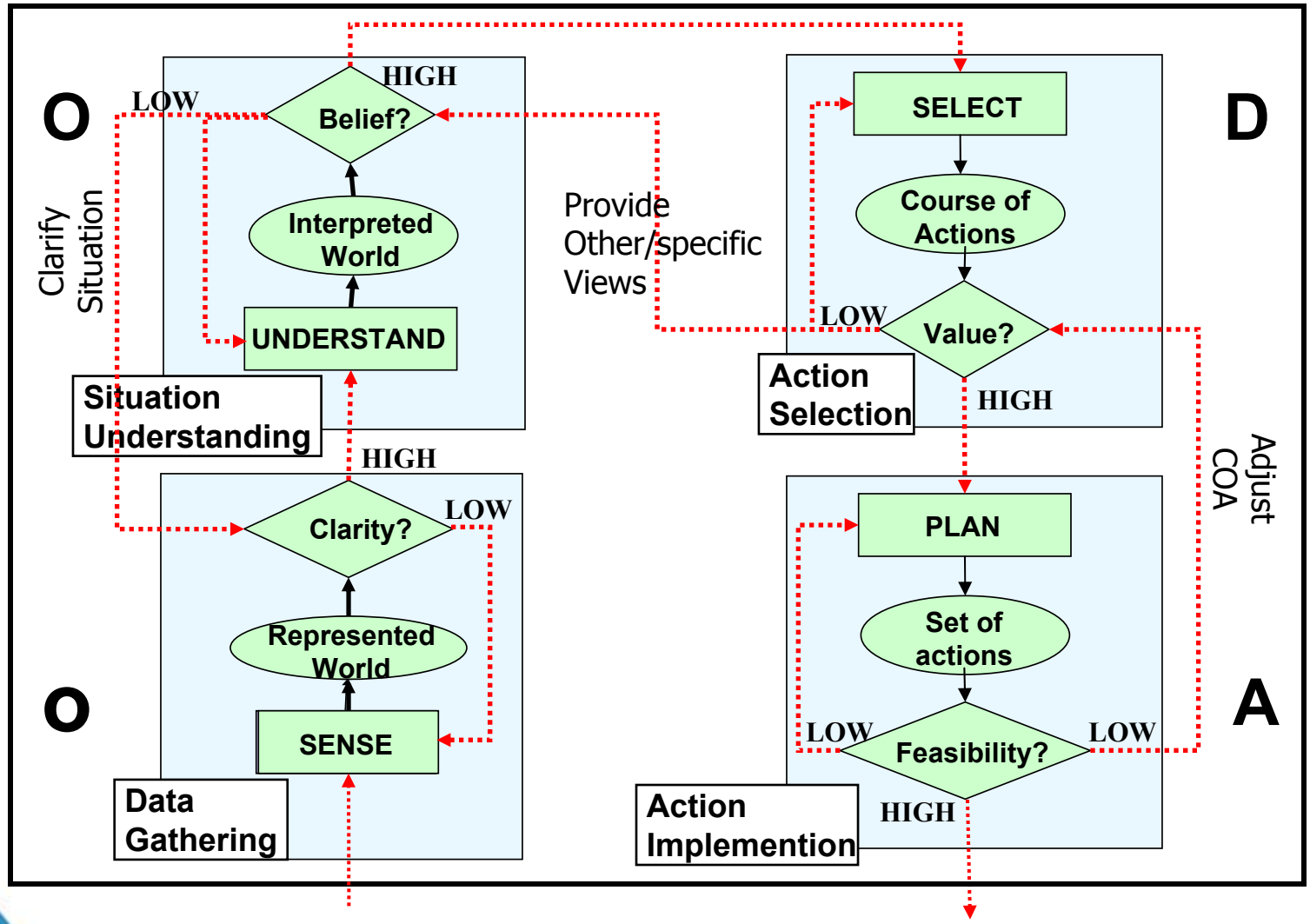


- ***Internal feedback loop (IL).***
  - an iteration request from the control component for
    - improved quality or increased quantity of state content
    - repeated processing of part of the input, or need for updating the content of state.
- ***External feedback loop (EL).***

There are two kinds of EL: The **Request loop** (R-El) and the **Transfer loop** (T-El).

- **R-El:** request for improved/new input addressed to the module that controls the input to a given module.
- **T-El:** passive transfer of the status of the current module to other modules or other non-task-goal related processes. The transmission of commander intent would flow downward through the T-EL.

The Architecture of the M-OODA Loop



Elements of Specification of the Core Components of the M-OODA.

Module	Process	State	Control
Data Gathering	Sense, encode, register, data translation, transduce, scan, fuse, detect, monitor	World representation, scene organization, multimodal-integration	Vagueness, completeness, fuzziness, time available, quality of picture
Situation Understanding	Identify, categorize, organize, schematize, recognize, form hypothesis, simulate	Mental model, schema, episode, familiarity estimation	Belief in interpretation, familiarity of schema, uncertainty on meaning
Action Selection	Select, choose, identify options, apply rules, consult,	Course of actions, risk evaluation, expected gain, selection rules	Risk assessment, completeness of options, cost assessment, gain estimation, familiarity of situation
Action Implementation	Taking action, planning, resource management, constraints identification, project management	Set of Actions, schedule, milestones, plan, mission, orders	Feasibility, acceptability, resource availability

The M-OODA Team Architecture

Basic modeling principles (Adapted from Breton & Rousseau, 2003)

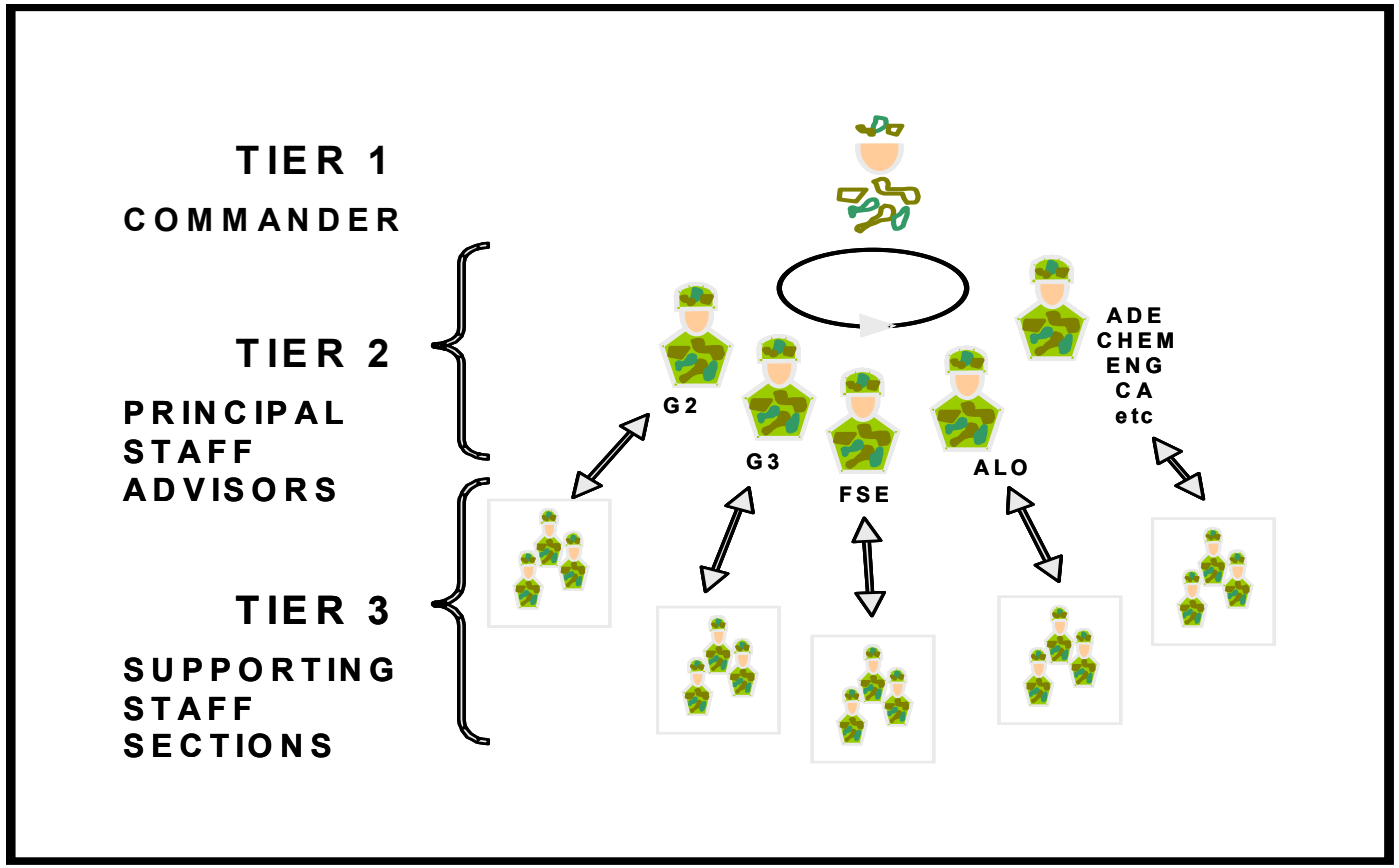
- **Team M-OODA is modeled by assuming:**
  - The Process and Control components in a module are owned by an agent.
  - Teamwork is modeled by repeating the Process and/or the State and/or the Control components within a given module. For the sake of simplification, a team is represented as three repeated components (e.g. three Process/State/Control boxes) in a module and agents are defined as human.
  - The type of Decision Making in operation in a given setting will determine the way agents are organized across and within DM sub-task modules. That will lead to Team DM models with different architectures.
  - An appropriate subset of Team Functioning Elements are then invoked to handle the required interactions between agents.

Team Functioning Elements (TFE)

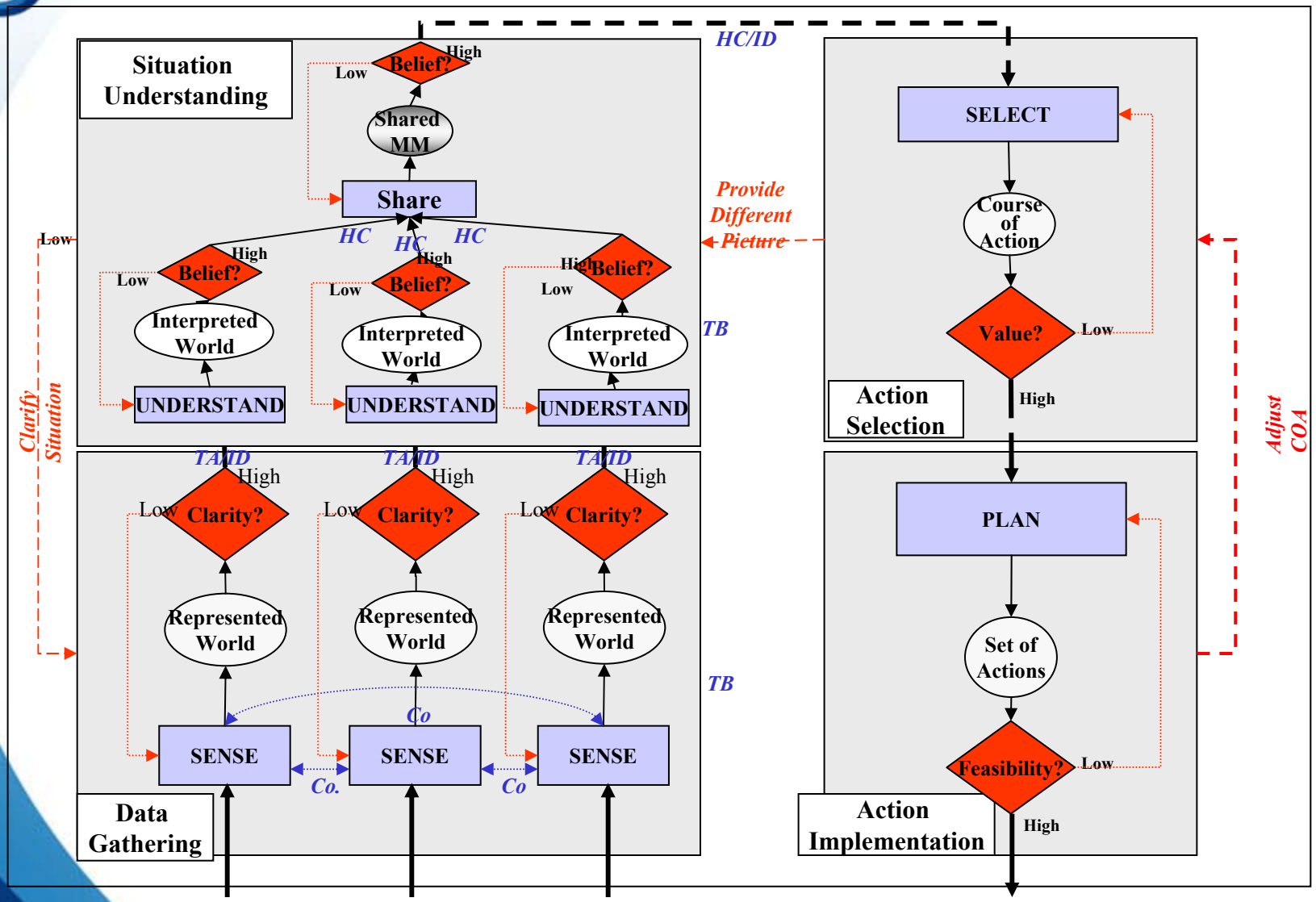
- TFEs are interactions between team agents associated with the quality and efficiency of teamwork.
- The set of TFE selected for the Team M-OODA models is taken from the NATO RTA IST-019 TG006. It includes:
  - Human Communication (HC),
  - Tool Communication (TC),
  - Coordination (Co),
  - Task Allocation (TA),
  - Task Balancing (TB)
  - Information Distribution (ID).

An example of Multi-Tiered Decision-making.

(Adapted from Leedom, 2000).



A M-OODA Model of Multi-tiered Decision-making.



Conclusion

- The M-OODA is a robust approach to descriptive modeling of military C2.
- It includes enough complexity to address the issues of team C2.
- The Control component requires further development given its central role in the M-OODA.
- Basic C2 simulators dealing with threat assessment will be used to test the issues of between module communication.