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# Computer Generated Forces - Background, Definition and Basic Technologies

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***Abstract***

*The paper starts with some background information on the requirements regarding the use of Computer Generated Forces (CGF). The term itself will be defined based on a definition already given by the US DoD. Basic or relevant technologies are described and an overview on their development given.*

# 1 Introduction

## 1.1 Background/History

The end of the Cold War has brought new military tasks and types of operations to NATO. These include regional contingency operations, Crisis Management and support of non-NATO missions (UN, PfP, WEU, etc.). All these have to be executed in a new environment with reduced forces and decreasing military budgets. The new geopolitical situation with expected reduced command levels and the need to co-operate between services as well as between nations, call for new concepts and systems.

Modelling and Simulation can be used as a tool to support the development of new concepts and systems for the future. M&S also help to better train and use existing forces and equipment and to improve operations in a new environment.

Emerging technologies will have a great impact on the implementation and on the military use of such simulation systems in the future. Computer Generated Forces as representations of forces in simulations which attempts to model human behaviour play a main part in this development. They offer support in different application areas; examples are thinking automated opposing (training and exercise), closed simulation systems (defence planning), Decision Support Tools (operations), and virtual environments (acquisition and procurement).

## 1.2 Present Situation

Computer Generated Forces are still used to some extent on lower levels of command and on weapon system level (e.g. Semi-automated forces). However their behaviour is stereotyped and only very simple levels of decision-making is addressed. Another approach for specific low level decision modelling is to use genetic algorithms. They are well suited for some optimisation problems, but are not sufficient to be used as a general tool for modelling human decision-making in simulations.

*Paper presented at the RTO SAS Lecture Series on "Simulation of and for Military Decision Making", held in Rome, Italy, 15-16 October 2001; Stockholm, Sweden, 18-19 October 2001; Virginia, USA, 23-25 October 2001; The Hague, The Netherlands, 10-11 December 2002, and published in RTO-EN-017.*

# Report Documentation Page

*Form Approved*
*OMB No. 0704-0188*



| | | |
|---|---|---|
| 1. REPORT DATE<br>**01 JUN 2003** | 2. REPORT TYPE<br>**N/A** | 3. DATES COVERED<br>**-** |

| | |
|---|---|
| 4. TITLE AND SUBTITLE<br>**Computer Generated Forces - Background, Definition and Basic Technologies** | 5a. CONTRACT NUMBER<br>5b. GRANT NUMBER<br>5c. PROGRAM ELEMENT NUMBER |
| 6. AUTHOR(S) | 5d. PROJECT NUMBER<br>5e. TASK NUMBER<br>5f. WORK UNIT NUMBER |
| 7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)<br>**NC3A, ORFS Division Oude Waalsdorper Weg 61 2501 CD The Hague The Netherlands** | 8. PERFORMING ORGANIZATION REPORT NUMBER |
| 9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) | 10. SPONSOR/MONITOR’S ACRONYM(S)<br>11. SPONSOR/MONITOR’S REPORT NUMBER(S) |

12. DISTRIBUTION/AVAILABILITY STATEMENT
**Approved for public release, distribution unlimited**

13. SUPPLEMENTARY NOTES
**See also ADM001513. RTO-EN-017, The original document contains color images.**

14. ABSTRACT

15. SUBJECT TERMS

| 16. SECURITY CLASSIFICATION OF: | | | 17. LIMITATION OF ABSTRACT | 18. NUMBER OF PAGES | 19a. NAME OF RESPONSIBLE PERSON |
|---|---|---|---|---|---|
| a. REPORT | b. ABSTRACT | c. THIS PAGE | | | |
| **unclassified** | **unclassified** | **unclassified** | UU | 41 | |

**Standard Form 298 (Rev. 8-98)**
Prescribed by ANSI Std Z39-18

In the short-term “Higher levels of command“ are considered for Army company/battalion or Marine Corps platoon/company level. For these levels programs are launched to develop so-called Command Forces (CFOR program in US).

On the higher levels of command at and above brigade at the moment Computer Generated Forces are available, that is not mature and could be used only for specific application areas (e.g. closed simulation models with decision tables in Germany).

CGFs are of considerable use in the areas operations and acquisition and procurement.

For military operations e.g. they could be used within operational C3I-systems to help decision making by modelling own decision processes and simulating the enemy as thinking opponent.

In defence planning as well as in acquisition and procurement Computer Generated Forces could be used as tools in building-up simulation systems to lay-out force structures and individual weapon components taking into account doctrines and tactics.

In supporting Computer Assisted Exercises (CAXs) CGFs could be used in the Response and White Cells and for the representation of a Thinking Opponent. This use will help to save money and personnel drastically.

# 2 Definition of CGF

The definition of CGF for LTSS/48 is mainly based on the definition given in the US DoD Modelling and Simulation (M&S) Master Plan. This definition read as:

*“A generic term used to refer to computer representations of entities in simulations which attempts to model human behaviour sufficiently so that the forces will take some actions automatically (without requiring man-in-the-loop interaction)".*

Modelling and Simulation (M&S) Master Plan
US Department of Defence Oct 1995

The term “forces“ in the definition of LTSS/48 is not restricted to military forces, because of civilian engagement in crisis and conflict scenarios. This term is defined as:

“Military entities as they are used in conflicts, peace support operations, and other engagements [operations] like disaster relief, and other civilian entities and individuals as they are engaged in actions represented in the simulation system.“

The distinguishing characteristic of CGFs is automatic decision making. For example, a manned simulator without a crew is not a CGF. It has no automated manner to act on the synthetic battlefield. Adding a human crew also does not make this simulator a CGF. In contrast, if a computer program that commanded it autonomously supplemented the tank simulator, this would now be an example of a CGF. In the context of constructive simulations (e.g. in an exercise using a simulation model) a battalion whose behaviour is determined by the computer may be viewed as CGF, though its quality is a matter of degree. If a human operator controls the battalion, the battalion is not a CGF.

The degree of automated behaviour can span a large range within this view of CGFs. Some applications will need relatively simple representations of decision-making, while in others the requirements are more severe.

# 3 Relevant Technologies

## 3.1 Introduction

This chapter is concerned with the five technology aspects that are most critical to the use of CGFs to reduce costs while at the same time increasing the quality of the application areas Training & Exercises, Defence Planning, Operations and Acquisitions. The classification of technology areas to support these applications is of course somewhat arbitrary, but the LTSS study group as a natural one quickly agreed upon the choice used here. It served the dual purpose of (hopefully) being instructive to the reader and was assumed to be productive to study group process. As far the latter objective was concerned, the group process showed that one class, namely Systems Science/Architecture, developed into mainly dealing with the architecture and modelling of CGFs. Consequently, a new group was formed dealing with (computer) Architecture.

The technology areas are defined in each of the respective subchapters, and are:

(1) Synthetic Environments

(2) Architecture

(3) Modelling of CGF

(4) Human Behaviour Representation

(5) Human/Systems Interactions

While 1 deals with the physical scenarios of CGFs, 2 deals with how to organise CGFs so that they communicate well between them and their environment. 3 and 4 deal with respectively the modelling of CGFs in general, i.e. the interaction between the virtual human and virtual physical entities. 4 discuss the methods for representing and modelling the outcomes of what in the real world are human behaviours and related decision processes. 5 investigate technologies for interfacing the CGF with a human decision maker or other operator.

## 3.2 Synthetic Environment

### 3.2.1 Definition

The LTSS working group on CGF derived a definition (based on the US DoD definition) for Synthetic Environments in the following terms, modification shown in underline:

> Synthetic Environments (SE), "*Internetted simulations that represent activities at an <u>appropriate</u> level of realism from simulations of theatres of war to factories and manufacturing processes. These environments may be created within a single computer or over a distributed network connected by local and wide area networks and augmented by realistic special effects and accurate behavioural models. They allow <u>interaction and</u> visualization of and immersion into the environment being simulated*".

The first modification reflects that a Synthetic Environment should only be represented to an appropriate level of detail required for the particular application domain. The second modification is the recognition that the Synthetic Environment allows the realistic interaction of CGF components rather than just their visualisation.

### 3.2.2 Content Requirements

The content of synthetic environments can be broadly categorised into three main components: the terrain itself and its representation, meteorological and illumination effects, and so called "man made" effects such as artificial objects and human caused changes of terrain features.

### 3.2.2.1 Terrain

(1) **Terrain Representation**. How should a synthetic terrain database be represented? Using TIN (triangular irregular network) is a convenient method of representing terrain because in real life terrain does not neatly form itself into a regular triangular grid with a fixed diagonal orientation. But this is more computationally expensive.

(2) **Micro Terrain**[1]. Could micro terrain representation be used when dealing with terrain features local to entities and using a coarser representation at distance, considering the effect on units using high level resolution.

(3) **Database Generation**. Inevitably, these databases need to be generated for the particular areas of interest. Currently, this is very time consuming, as much manual labour is required to ensure consistent and realistic databases. As part of the US ASTT (Advanced Simulation and Technology Thrust) programme, ways of automating this process such that databases can be ready in 8 hours are being researched.

### 3.2.2.2 Meteorological, Illuminants

(1) **Weather**. The effect of weather can play an important role during operations. Not only does it have an immediate/direct effect (visibility, performance of equipment), but also a time dependent effect by changing the state of the terrain (rain making ground bogging, which eventually dries out again). Thus considering at the entity level, weather affects physical characteristics (such as trafficability, speed, etc), sensory systems (such as sights, laser and so on) and human behaviour (such as temperature effects).

(2) **Illumination**. The terrain can essentially be illuminated by a number of sources: the sun, the moon, flares and lights. Although relatively simple to model solar illumination, other sources are very important especially at night, when night vision or infrared detection systems are employed. Much harder to model (and display on a monitor) is glint from a reflective surface (e.g. a pair of binoculars), which is usually generated from a small surface, at some distance and is highly angular dependent. Glint from a vehicle is a major attribute to detection of hidden vehicles.

(3) **Sea state**. This generally has concentrated on the land-sea interface (the surf zone), however the effect of sea state is important for Maritime operations. For example, the sea state affects sonar performance (mine and submarine detection), bottoming out, communications, and so on. The depths of seas are seen to be part of the terrain description.

(4) **Air state**. Similar to sea state, the state of the air has performance on radar, aircraft performance and so on. This implies detailed modelling of cloud, air content, air currents etc.

(5) **Other**. This covers other types of effect such as smoke and chemical clouds. Deployment of smoke is a very important operational tactic (e.g. obscurant), and as such requires representative modelling.

### 3.2.2.3 Artificial Objects and Effects

(1) Dynamic Terrain. In real battles the terrain is altered either by consequence (shelling, detonations) or by design (protection such as ditches, trenches, etc). These effects cause changes to the terrain surface (craters) or to objects (destruction of bridge), or to both (road damage). In the case of the terrain, the representation needs the ability to be modified to reflect the change. In the case of the objects, these need to have multiple states (especially trees!), or for complex

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[1] Normally the terrain surface is represented as a regular grid of spot heights (e.g. 125 m intervals). However, in some applications it is necessary to resolve the skin at a higher resolution in some areas, for example to represent a bunker (e.g. 10m), in which to place a tank.

objects multiple states of sub-objects (e.g. rooms in a building). This is a hard problem, because the change must reflect on all instances of the database. Are the changes computed on a central database server then farmed out to the various simulators? Or, perhaps adopt the HLA philosophy that simulators register to a central database server their areas of interest. In any case traffic is passed over a network. It must be ensured to reach its destination and in a causally correct fashion.

## 3.3 Simulation System Architecture

### 3.3.1 Introduction

This Working Group was created in response to the recognition that there is more to military simulation systems than the important content of the CGFs themselves. CGFs are only meaningful within a context that includes an entire simulation (or operational) SYSTEM: the CGFs, the MMIs, the Synthetic Environment, the human behavioural models (HBMs) and other components discussed more fully in Section 2. Although CGFs may indeed be useful in a number of applications not requiring all of the above components, many of the future uses of CGFs will involve applications requiring the integration with live systems (e.g.C4I), the incorporation of multi-modal man-machine interface devices, the flexible combination of different CGFs, and the embedding of the CGFs into very different types of synthetic environments. The issue here is to not just develop an architecture that can allow reasonable interoperability of today’s CGF components and capabilities, but rather to set down the framework and issues in order to create an appropriately flexible and open architecture for the future wide-ranging applications of CGFs. Part of the required flexibility and openness is not only for the economic and scientific benefits of quickly building CGF applications out of existing, diverse components, but also to give different countries the flexibility to participate to the extent that they want to in different applications, while still retaining the advantages of leveraging off of each others’ investments and developments in this area. This is an important part of the strategy for leveraging off the commercial marketplace while retaining the requirements for specialised military systems; flexible architectures allow commercial partners to participate to different degrees.

Based on the collective experience of the team, we started with some important assumptions about the type of requirements we will need for a sufficient simulation architecture for CGFs. (listed below) We then spoke to each working group about the system level architectural issues from their point of view, and used that feedback to adapt our conclusions and recommendations.

This Working Group was chartered with describing the important architectural issues in developing such a simulation system, and identifying which of the long-term goals of the 1.Section (Application) Working Groups need to be addressed as system architecture issues. We also made some starting assumptions because of our experiences in large-scale architecture development:

Architectures must be specialised not only by task and domain, but also by specific classes of users.

Successful architectures have to be driven by customer pull as a well a policy push otherwise they will become obsolete due to economic forces.

Heterogeneous communities may require different architectural services with different constraints at each layer. Appropriate incentives can help individual and groups to see co-operating in shareable architectures as an advantage; the shared infrastructure and reusable components must be harvested, and made easy to use and access globally

Good simulation architecture should increase object reuse, decrease system risk, time to insert the technology, and eventually model development and maintenance costs.

Interoperability is matter of degree, depending upon the needs of the simulation, training, and C4I communities.

A simulation object repository provides information on objects, their public attributes, associations, interactions, level of resolution, and key models and algorithms used to represent entities in the simulation.

Simulation architecture needs common transport layers, common messaging systems, and neutral data formats to provide limited interoperability and maximum flexibility. This will allow commercial companies and developers to gradually “buy-in” to joint applications.

Systems integration at the communication level is a necessary but insufficient goal. Semantic integration via common ontologies is the critical challenge.

Selection of open architecture and protocols needs to track trends and standards in the commercial world in order to leverage off commercial investments for specific military uses.

### 3.3.2 Architecture of Simulation Systems

Architecture is critical for rapid construction and reuse of simulations and simulation components, because it defines the roles and responsibilities of the components in the larger system, including not only their interfaces with each other but also the semantics of their expected interactions. It allows those roles to be abstracted, so that other modules or components can be used instead, provided they perform the same roles and carry out the same responsibilities. This feature allows interchange of different components among different systems when the usage specifications agree.

The question is not *whether* to have an architecture. There is always an architecture when there is more than one function computed. The question is whether to make the architecture *explicit*, so that it can be designed and studied like any other part of a complex system. It is important when we use simulations to make informed decisions that we know what the effects of the architecture on the results are. Furthermore, we want to increase the flexibility and as openness of the CGF architectures for all the scientific and economic reasons cited above. Clearly, there are trade-off studies that will determine how much time and money should be spent to improve the openness and flexibility of CGF architectures, and that is one of the important reasons for these topics to be included in studies like this. However, it is also the opinion of this expert working group that the requirements for relatively open architectures are almost always underestimated in the military applications where there are serious needs to quickly improve the performance of existing systems with the newest capabilities. It is also our opinion that even preliminary results have shown the benefits for military systems of reasonably open architectures.

Because architecture is an integration concept, a way to provide a common semantic framework for a collection of models, or to put back together components that have been developed separately, our Working Group discussed important issues with the other Technical Working Groups, to identify those that are primarily architectural issues or that would affect or be affected by any proposed architecture.

Our purpose in this Working Group was not to propose a particular architecture, or even an architectural style, but to identify properties that any architecture should have, and to collect context conditions that any architecture should accommodate. No single architectural style suffices for all the different applications of CGFs or all the different uses of simulation. Each simulation developer will of course have a unique mix of requirements and application interests, so the architecture that will be used will depend on that mix. Our purpose in this Working Group was to show how new developments in system architectures can help make these separate systems interoperate more easily.

A simulation system will have many different kinds of components: CGFs, Synthetic Environments, Models of domain entities, forces, tasks, Analysis Tools, Scenario Generation Tools, Visualisation Tools, Mobile Devices, Multimodal Human-Machine Interfaces, C4I systems, Embedded evaluation and monitoring agents, algorithms for continuous, discrete event and Monte Carlo simulations, embedded tutor components, tools for after action review, and many other kinds of automated assistance. In addition to these resources that have immediate utility to the user, there are a number of resources that are necessary components to managing these resources in a flexible way; they are indirectly seen by users in the ease with which the system can be tailored because of the needs of different users, new field requirements or new parts of the system. Among these types of components are domain-specific models that define the configuration for a subset of components, with the detailed specialisations that will allow them to be tailored for a given application.

Even though we can take advantage of good object-oriented approaches and the use of meta-data approaches, a single object or component cannot contain inside itself all of the information required at the whole system level. That is, local consistency of the information within an object, or even each one of a collection of objects, does not guarantee global consistency. There are many attributes of a system that must be analysed (generally using different methods) at both the whole system and the local levels (e.g., risk, performance, validity).

It is our view that the system should perform as much component integration and management as possible, instead of the organisation or simulation owners, because automatic assistance makes it much more likely that the simulation components are consistent with each other and with the assumptions of the simulation study, much more likely that the component interfaces are properly used, and much more likely that automatic reconfiguration and instrumentation tools can be used successfully.

Even if we were all to agree that this list is complete, i.e., it contains all of the important components of a simulation system, we still need flexibility in the architecture, because components and even architectures change with technology. That is, the variety of components, the different kinds of uses of components, and the dynamic nature of technology, together requires a flexible interconnection architecture. It is therefore necessary to define the semantics of the shareable data, that is, the meanings that the users of that data are expected to attach to it, rather than fixing the structure if the systems that will use the data. It is convenient to define the syntax of the data (data formats and structures), but not nearly as important as defining the semantics. If the data syntax is explicit for each data item, then it can be translated or converted appropriately as needed.

## 3.4 Modelling of CGFs

### 3.4.1 Introduction

The scope of this section is to identify the technologies required to achieve good rational / cognitive models within a CGF.

One basic assumption is that the physical behaviour of the computer-generated force is fairly well understood whereas the rational and human factors aspects are not. Another assumption is that a good rational / cognitive model of a CGF can be incorporated into any simulation that represents its physical part or into its real-world physical component.

As the architecture of the simulation system plays an important role in the effective use of CGFs, it will be discussed briefly in this section. Next, a generic structure of the rational / cognitive part of the CGF will be described. The technologies that are relevant for the development of each of the modules in this structure are derived. The criticality and maturity of these technologies and the likelihood of being developed for commercial purposes are assessed. Combined with an overall analysis of the contribution of CGFs to the various application areas long-term objectives, a ranking of the technological areas that require military funding is derived.

### 3.4.2 Architecture

The architecture of a simulation system as shown in Figure 1 enables a flexible organisation of the elements of the simulation, based on the requirements of the area where it will be applied.

The existence of a common “language” allows heterogeneous elements to interact. Furthermore, the same element can be implemented in different ways without impacting on the rest of the simulation. In Figure 1, this common language is referred to as “Interoperability Protocol”.

The interoperability protocol consists of three layers:

(1) The communication layer, which provides the mechanism for the physical transport of messages between the components of the simulation system.

(2) The “grammar” layer, which provides the words and rules for building the messages.

(3) The “semantics” layer, which contains the “dictionary” to attribute meaning to and extract meaning from the messages.

C3I systems, either in an operational or a training mode, are integrated into the simulation system. For training or analysis, a duplication of an existing C3I system or a prototype of a new C3I system can be inserted into the simulation in order to avoid disruption to the real-world operational C3I system.

In analogy to the C3I system, interaction with the environment can take place with a synthetic or a real-world representation. The specific characteristics of the synthetic environment are addressed in section 4.2.

The particular part of the architecture dealing with the rational / cognitive model of CGFs and their interaction will be described in the following paragraphs. The part of the architecture dealing with CGFs and their interaction to humans involves different techniques and will be addressed in section 4.6.

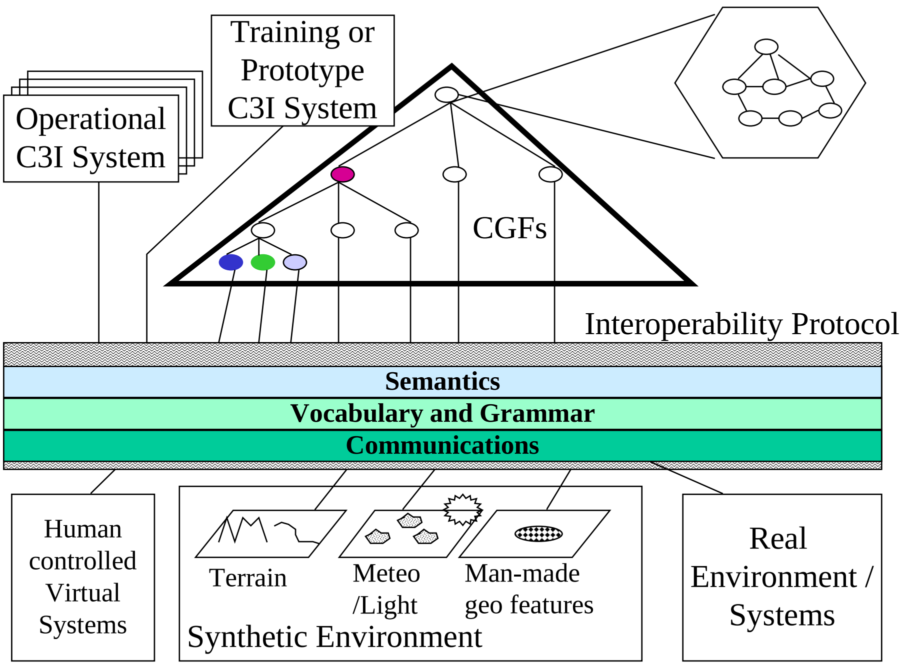


Figure 1: A potential Simulation System Architecture

### 3.4.3 CGF modules

As shown in Figure 1, the organisation of the CGFs should reflect the structure of the organisation they represent. In case of a military organisation, this generally implies a strictly hierarchical structure. Within a military staff, however, this strict hierarchy does not necessarily apply and a collaborative group decision-making structure needs to be reflected. Hence a CGF representing a specific level of command would be broken down into a number of CGFs representing its respective staff elements. To communicate to each other, the CGFs would use the interoperability protocol discussed in the previous section.

Considering the ability to represent all elements of the civil / military organisation, it is suggested that a sufficiently detailed model to meet the various application areas’ requirements could be a solution to simulating at various levels of information aggregation. Indeed information would be processed through CGFs down to the level of detail of the synthetic environment and would be reported upwards through CGFs to the required level of information presentation.

In order to derive basic technologies to develop good CGFs, the internal structure of a CGF was developed, as illustrated in Figure 2. This proposed structure is derived from a model of the decision making process. Alternative structures could be defined based on a different model. Each of the modules corresponding to a step in the decision making process can be characterised by a set of functions. It can be expected that alternative structures would also include these basic functions.

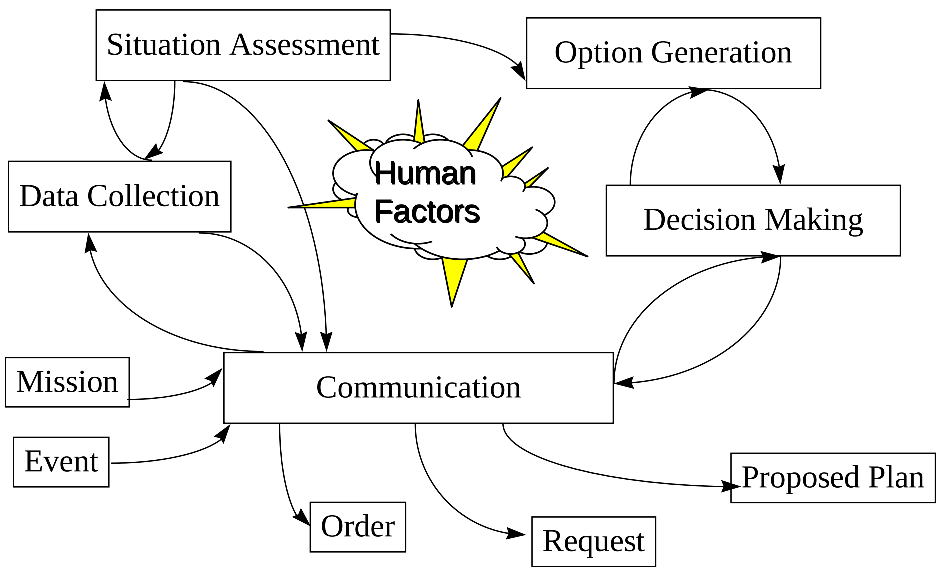


Figure 2: Modules of the CGF rational / cognitive model

The role of each of the modules can be described as follows:

(1) the data collection module is responsible for gathering the detailed data elements as instructed by the situation assessment module;

(2) the situation assessment module defines the detailed data requirements that need to be collected, interprets the mission received by the CGF, updates the current assessment of the situation and defines and monitors critical and meaningful events;

(3) the option generation module develops courses of action based on the triggering event, mission statement and current situation assessment;

(4) the decision-making module evaluates the various courses of action and ranks them according to a set of pre-determined and derived criteria. It will also support the negotiation process between CGFs or human decision makers that may be required to develop a solution for the larger context in which the CGFs decision is included;

(5) the communication module supports the exchange of data between the CGF and all other elements of the simulation system. It transforms data into the appropriate format for local and external interpretation.

The sequence of decision-making steps can be either course of action or goal driven. Some of the modules e.g. situation assessment, may operate in parallel with others while others e.g. option generation need to be triggered specifically. Human factors like stress, fear, fatigue etc. have their influence on all of the decision-making steps. They are, however, considered to fall outside the scope of this section.

Each of the modules are defined as consisting of the following functions:

| Module | Function | Description |
|---|---|---|
| Data Collection | Get data request | Receive detailed data specification |
| | Find the data | Query sources<br>Define sources |
| | Prepare the data | Format retrieved data |
| | Provide data reference | Report on data source |
| Situation Assessment | Produce data requests | Specify detailed data requirement |
| | Interpret and fuse data | Merge and attribute meaning to data |
| | Monitor critical events | Define critical and meaningful event criteria. Monitor events and assess impact. |
| | Maintain updated situation | Adapt perception of current situation and verify consistency. |
| Option Generation | Generate possible courses of action | Taking into account mission, environment, own and other forces, develop feasible courses of action (including empty set) |
| Decision Making | Rank options | Derive variable criteria.<br>Combine pre-determined and derived criteria.<br>Analyse courses of action. |
| | Goals decision making approach | Derive intermediate goals. |
| | Negotiate | Re-define constraints and range of acceptable solutions. Monitor and enforce convergence. |
| Communication | Interface | With external elements and CGF |
| | Report | To other CGFs and external elements |

Table 2: Functions of the modules of the CGF rational / cognitive model

| Module | Function | Technology | Criticality |
|---|---|---|---|
| Data Collection | Get data request | Current database and browsing technologies | H |
| | Find the data | Data mining (e.g. Selection and discrimination techniques) | H |
| | | Knowledge discovery | L |
| | | Pattern recognition | L |
| | | Knowledge based systems | L |
| | Prepare the data | Current database and browsing technologies | H |
| | Provide data reference | Current database and browsing technologies | H |
| Situation Assessment | Produce data requests | Knowledge discovery | H |
| | | Translation techniques | H |
| | | Rule-based systems | H |
| | Interpret and fuse data | Task and domain specific data fusion algorithms | H |
| | | Pattern recognition | H |
| | | Neural networks | M |
| | | Image recognition | M |
| | | Natural language processing | H |
| | Monitor critical events | Flexible object schema for situation description | H |
| | Maintain updated situation | Blackboards for consistency maintenance | H |
| | | Knowledge based systems | H |
| Option Generation | Generate possible courses of action | Search algorithms | H |
| | | Simulation | M |
| | | Knowledge based systems | H |
| | | OR | L |
| | | Fuzzy logic | M |
| Decision Making | Rank options | Simulation | H |
| | | OR | H |
| | | Fuzzy Logic | H |
| | Goals decision making approach | Planning techniques | H |
| | | Search techniques | H |
| | Negotiate | Cooperative planning | HH |
| Communication | Interface | Speech recognition | H |
| | | Image recognition | H |
| | | Gesture recognition | L |
| | Report | Speech generation | M |
| | | Image generation | M |

Table 3: Technology areas relevant to the CGF functions

### 3.4.4 Basic technologies

Having defined the various constituent functions, the technologies required to develop them can be listed. They are shown in Table 3, along with an appreciation of the criticality of the technologies to the specific function of the CGF module. Criticality is measured as being H(igh), M(medium) or L(ow).

## 3.5 Human Behaviour Representation

This section is concerned with one single aspect of a CGF - how human decision-making behaviour is represented within a typical CGF. Common understanding, also reflected in the technology working group responsible for examining this technology area, is that Human Behaviour Representation (HBR) is the most difficult issue in devising successful future CGFs with high quality. Technically, one can think of a HBR as a software module that "interacts" with the rest of a CGF and/or with the real world - depending on the application. This interaction must be controlled through the simulation architecture, via HBR objects that access information from real or simulated sensors through real or simulated C4I systems. The nature of this interaction is described in the CGF Modelling and in the Architecture chapters and will only briefly be referred to here.

There are two main approaches to HBR. One is mainly concerned with mimicking human thought processes and is hence here called HBP (Human Behaviour Process). The other is more concerned with a correct representation of the output of a thought process, and is here termed HBO (Human Behaviour Output). The implementation of HBR in software is here referred to as HBM (Human Behaviour Model).

## 3.6 Human/System Interactions (H/S-I)

In the following are short, mid, and long-term technology solutions for H/S-I systems in CGF described. Short term is defined as currently off the shelf or within three years of being off the shelf. Mid term is defined as from 4 to 10 years out and long term is from 10 to 15 years out.

### 3.6.1 Results and Timelines for Training and Exercise Problem Areas

Table 4 briefly lays out the results for training and exercise.

| Training & Exercise | Short | Medium | Long |
|---|---|---|---|
| Natural interface | • Speech recognition<br>• video conferencing<br>• realistic graphics<br>• gestures for gross manipulation | • Facial expression recognition<br>• natural language processing<br>• reliable gesturing<br>• systems | • Realistic voice synthesis<br>• VR<br>• transparent & natural interface |
| Time compression | • Expansion to allow students to catch up<br>• compression to save time, may be used to create stress | • Study effects of time compression on learning and operational performance<br>• alternative training and pre-exercise strategies | • Can the manipulation of time simulate wartime stress |
| Multi-modal | • Output: audio, still & motion video, graphics.<br>• Input: keyboard, mouse/ trackball, touch panels, single utterance speech.<br>• Video conferencing has elements of all | • R&D into adding modes (touch, pressure, tactile).<br>• Improve current modes (360 sound), 3-D.<br>• What is the effect of cultural influences and individual differences on interface effectiveness | • Smell, taste.<br>• Using human sensory system to create stress.<br>• Total immersion systems. |

Table 4: The working groups results for training and exercise

Most of these technologies are being developed independently of any military or NATO intervention since they would add value to commercial computer products as well. However, there are two research areas, which should be pursued as a result of this conference:

(1) The effects of time compression and expansion on learning and performance

(2) The effect of cultural differences on interface design and effectiveness.

### 3.6.2 Results and Timelines for Defence Planning and Operational Analysis Problem Areas

Table 5 provides the timeline for the issues raised by Defence Planning and Operational Analysis.

| Force Planning | Short | Medium | Long |
|---|---|---|---|
| Abstract concepts | • Text<br>• maps<br>• flags<br>• simple icons | • Media resources analysis<br>• cultural metrics<br>• probability of particular events | • Set realistic and limited goals<br>• Program should be a series of well defined, short term projects |
| Drill down | • Lot of data<br>• problem is converting to information<br>• Primarily self selection | • Optimum data base organisation for human use<br>• What information is needed by whom and when do they need it? | • Intelligent agents subject to verification |

Table 5: Timeline

The primary research goals here are to establish ways to organise data to that can be used by the right people at the right time. A separate, but equally difficult problem, is to capture abstract concepts (i.e., religious beliefs, tribal loyalty) in some concrete form that can then be represented in a useable form for decision makers and planners.

The need for intelligent agents, which are subject to verification, should also provide a high priority research thrust. Commanders want information they can trust. An intelligent agent must provide that information and also be able to respond to queries about it. The information provided should not be more precise than the truth based on “fog of war”. Therefore there are two research areas recommended by the H/S-I working group to meet the Force Planning needs:

(1) How to represent abstract concepts in operationally meaningful terms.

(2) The development of intelligent agents, which can be subjected to verification.

### 3.6.3 Results and Timelines for Operations Technologies Problem Areas

Table6 provides the timeline for H/S-I responses to the Operations area.

| Operations | Short | Medium | Long |
|---|---|---|---|
| Agents | • Organisers<br>• formats<br>• push technology | • Inference agents (what information do staff need?)<br>• Use simulation to determine what is the necessary and sufficient information for decision making | • Intelligent agents subject to verification |
| Expressing the complex | • Improved navigational techniques<br>• advanced graphing<br>• visualisation<br>• display of multidimensional data | • Develop a theory for display of multidimensional, complex information | • Automated processing and displaying of complex data.<br>• Task and individual based display |
| Random insertion of unplanned events | • Stochastic models<br>• unexpected failures | • Critical event detection<br>• automated checklist for critical event detection<br>• automated dissemination of warnings | • Automated detection of critical events<br>• display of critical events |

Table6: Timeline

# 4 References


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Report of the Defense Science Board Task Force on Simulation, Readiness and Prototyping, Office of the Under Secretary of Defense for Acquisition Washington, DO 20301-3140, January 1993.

Schmidt, W.H.P. "Computer Assisted Exercises (CAX), A Technological Challenge to NATO", *SHAPE Technical Centre Professional Paper 305*, The Hague, August 1992

# CGF – Background, Definition and Basic Technologies

Dr. Uwe K.J. Dompke

NATO C3 Agency

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# Topics

- Definition of CGF
- Background
- Basic Technologies

# Notes for Slide 2

The **Logical or Functional Perspective**. This view focuses on the logical or functional interrelationship of the CAX System Components and constitutes the **Functional Architecture of the CAX System**. The Functional CAX Architecture described in 1 is derived from military operational needs and it is not constrained by any system topology or other CAX System Implementation considerations.

The **CAX System Topology**. This view defines and evaluates available options for providing the CAX functionality. As the first step in this process, six options are identified, each with a different degree of integration of CAX with CCIS and with a different degree of distribution of the CAX functionality itself. The second step is then to compare the CAX Architectural Options and come up with advantages and disadvantages of each of them. This analysis, provided in Section 2, is based on the Functional Architecture as well as on a set of assessment criteria such as User Satisfaction, Implementation/Operation & Maintenance Cost, Security, Technological Trends and Flexibility.

# Notes for Slide 2 (Continued)

The **CAX System Physical Architecture** describes hardware and software components and their interrelationships for the CAX system. In future CCIS, as in other modern information systems, this physical architecture will not play the role it is playing today. New technologies available to implement functions on distributed systems and global data links will make it possible to concentrate on the functional and topological design of the systems. Even changes from one physical architecture to another regarding the distribution of functions in a network will be no major problem and will give the opportunity to decide on topological architectures as described in chapter 2 in accordance with the exercise requirements. Chapter 3 introduces the discussion on possible implementation options for the different topological CAX architectures.

# Definition of CGF

***"A generic term used to refer to computer representations of entities in simulations which attempts to model human behaviour sufficiently so that the forces will take some actions automatically (without requiring man-in-the-loop interaction)".***

**Modelling and Simulation (M&S) Master Plan**

**US Department of Defence Oct 1995**

# Definition of CGF from LTSS/48 on CGF

***The term "forces" in the definition of LTSS/48 is not restricted to military forces, because of civilian engagement in crisis and conflict scenarios. This term is defined as:***

**"Military entities as they are used in conflicts, peace support operations, and other engagements [operations] like disaster relief, and other civilian entities and individuals as they are engaged in actions represented in the simulation system."**

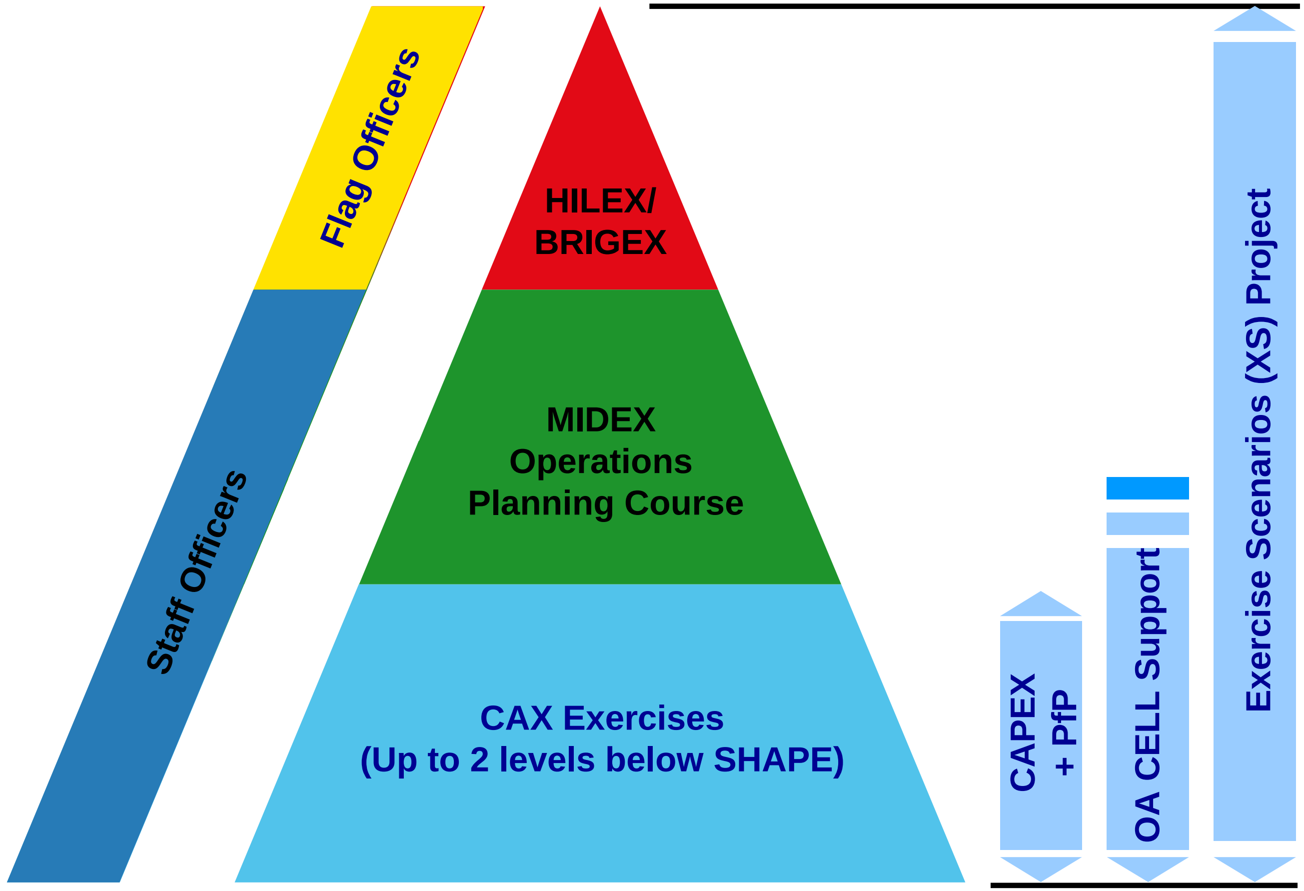
## Background

- Assumption That a Good Rational/Cognitive Model of a CGF Can Be Incorporated Into Any Simulation That Represents Its Physical Part or Into Its Real-world Physical Component
- The Physical Behaviour of the Computer-Generated Force Is Fairly Well Understood Whereas the Rational and Human Factors Aspects Are Not
- CGF Still Used on Lower Level of Commands

# Application Areas

- **CGF Offer Support in Different Application Areas:**
  - **Training and Exercise**
  - **Defence Planning**
  - **Support to Operations**
  - **Acquisition and Procurement**

# NC3A Exercise Support Scope



# Application Areas

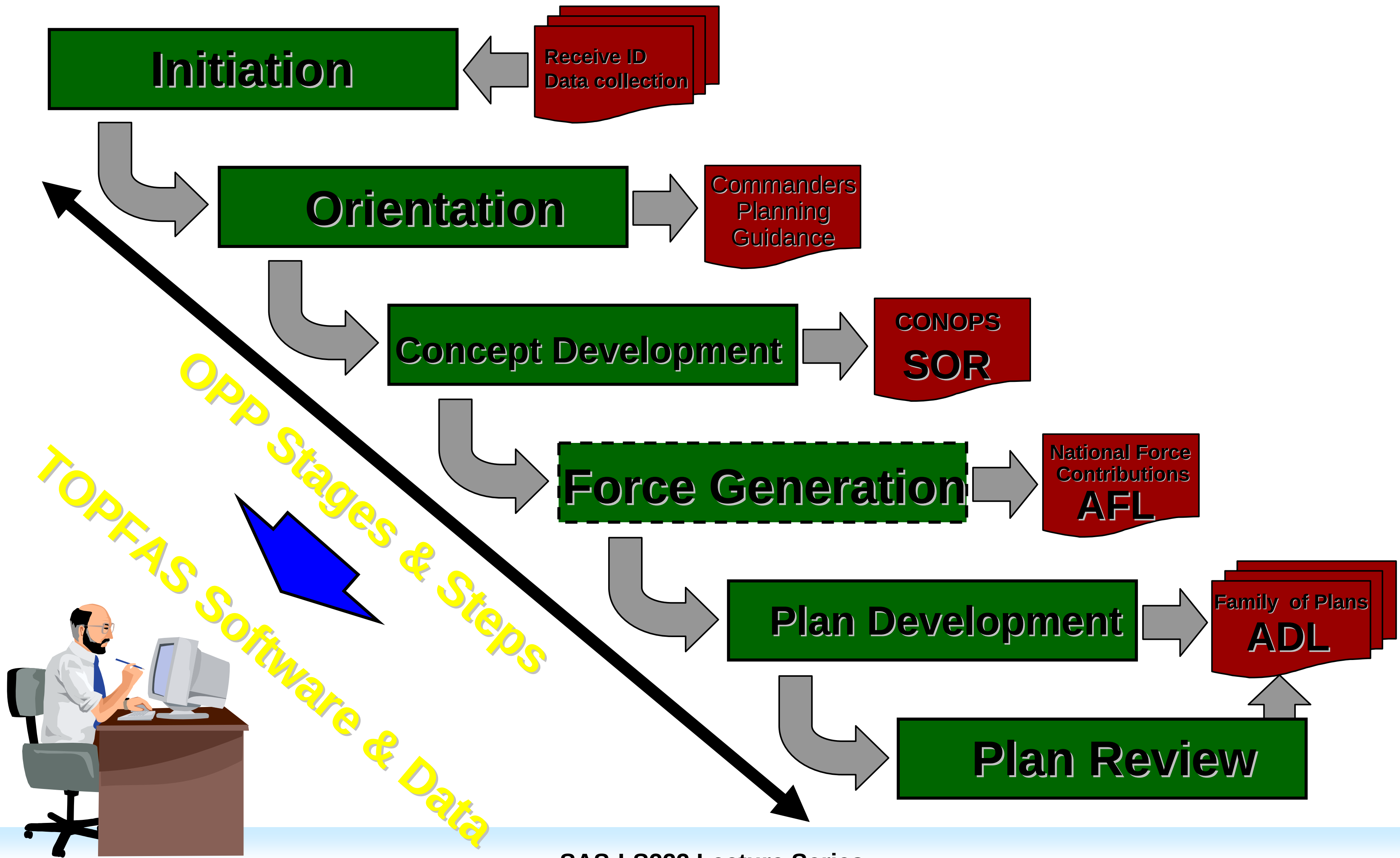
- **CGF Offer Support in Different Application Areas:**
  - **Training and Exercise**
  - **Defence Planning**
  - **Support to Operations**
  - **Acquisition and Procurement**

# Defence Planning Support

# Application Areas

- **CGF Offer Support in Different Application Areas:**
  - **Training and Exercise**
  - **Defence Planning**
  - **Support to Operations**
  - **Acquisition and Procurement**

# The OPP Steps and TOPFAS Functionality



# Application Areas

- **CGF Offer Support in Different Application Areas:**
  - **Training and Exercise**
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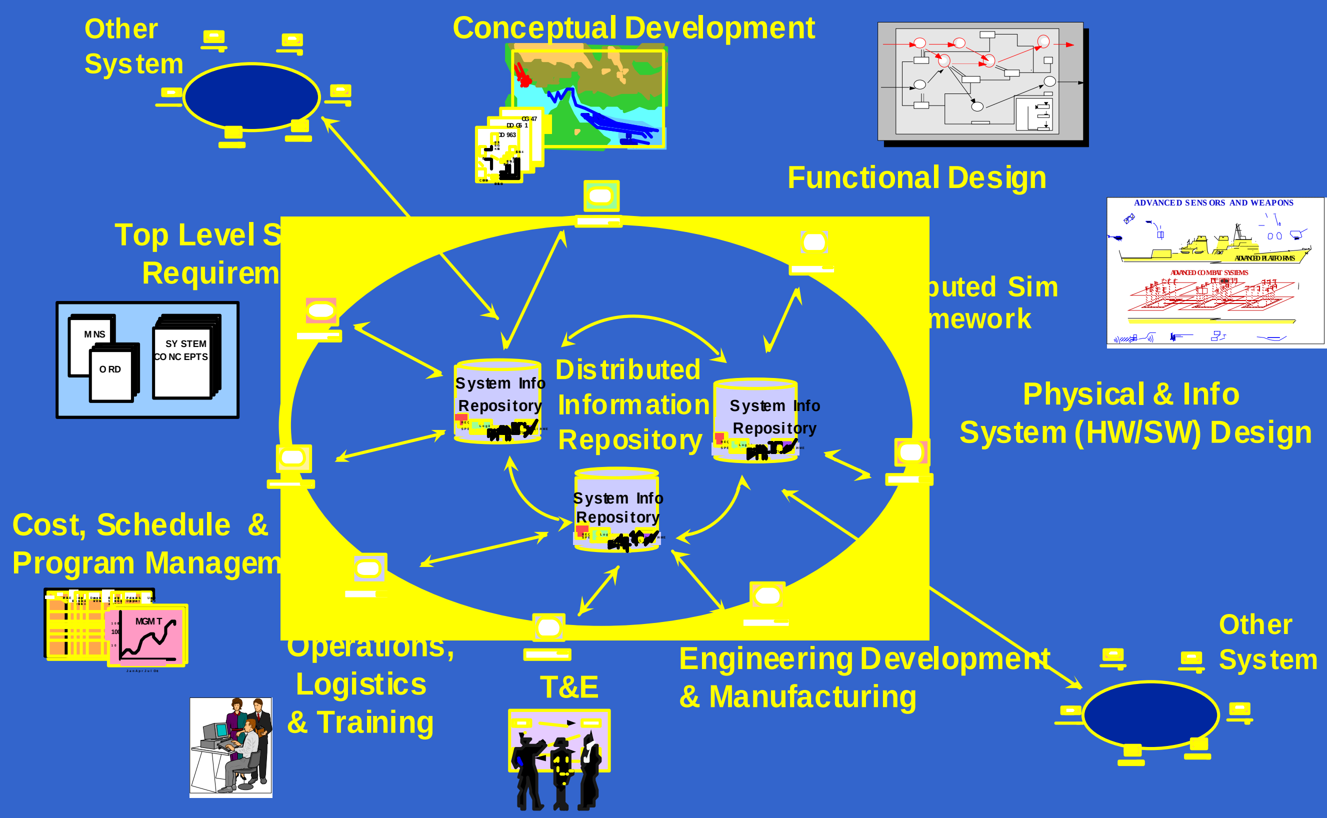
  - **Acquisition and Procurement**

## SBA OPERATIONS CONCEPT




**Extensive Re-use Within Phases and Across Acquisition Programs**

# Basic Technologies

- **Synthetic Environments**
- **Simulation System Architecture**
- **Modelling of CGF**
- **Human Behaviour Representation**
- **Human/Systems Interactions**

# Synthetic Environment Definition

**"*Internetted simulations that represent activities at an appropriate level of realism from simulations of theatres of war to factories and manufacturing processes. These environments may be created within a single computer or over a distributed network connected by local and wide area networks and augmented by realistic special effects and accurate behavioural models. They allow interaction and visualization of and immersion into the environment being simulated*".**

# SE Content Requirements

- **The Terrain Itself and Its Representation**
- **Meteorological and Illumination Effects**
- **So Called “Man Made“ Effects Such As Artificial Objects and Human Caused Changes of Terrain Features**

# Terrain

- **Terrain Representation**
- **Micro Terrain**
- **Database Generation**

# Meteorological, Illuminants

- **Weather**
- **Illumination**
- **Sea state**
- **Air state**

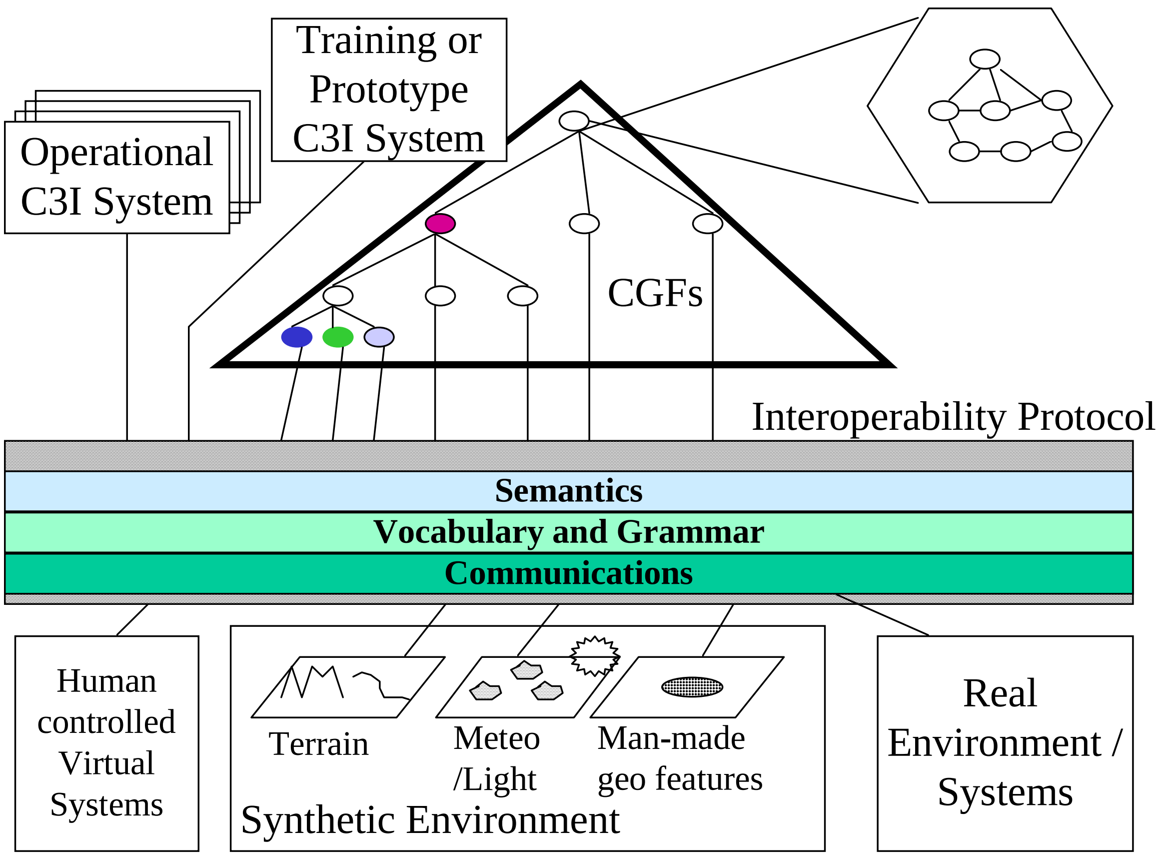
# Artificial Objects and Effects

- **Dynamic Terrain - Terrain Is Altered Either by Consequence (Shelling, Detonations) or by Design (Protection Such As Ditches, Trenches, Etc)**
  - **Changes to the Terrain Surface (Craters) or**
  - **To Objects (Destruction of Bridge), or**
  - **To Both (Road Damage)**

## Simulation System Architecture

- **Need for an Appropriately Flexible and Open Architecture for the Future Wide-ranging Applications of CGFs.**
- **Economic and Scientific Benefits of Quickly Building CGF Applications Out of Existing, Diverse Components Even Multinational**

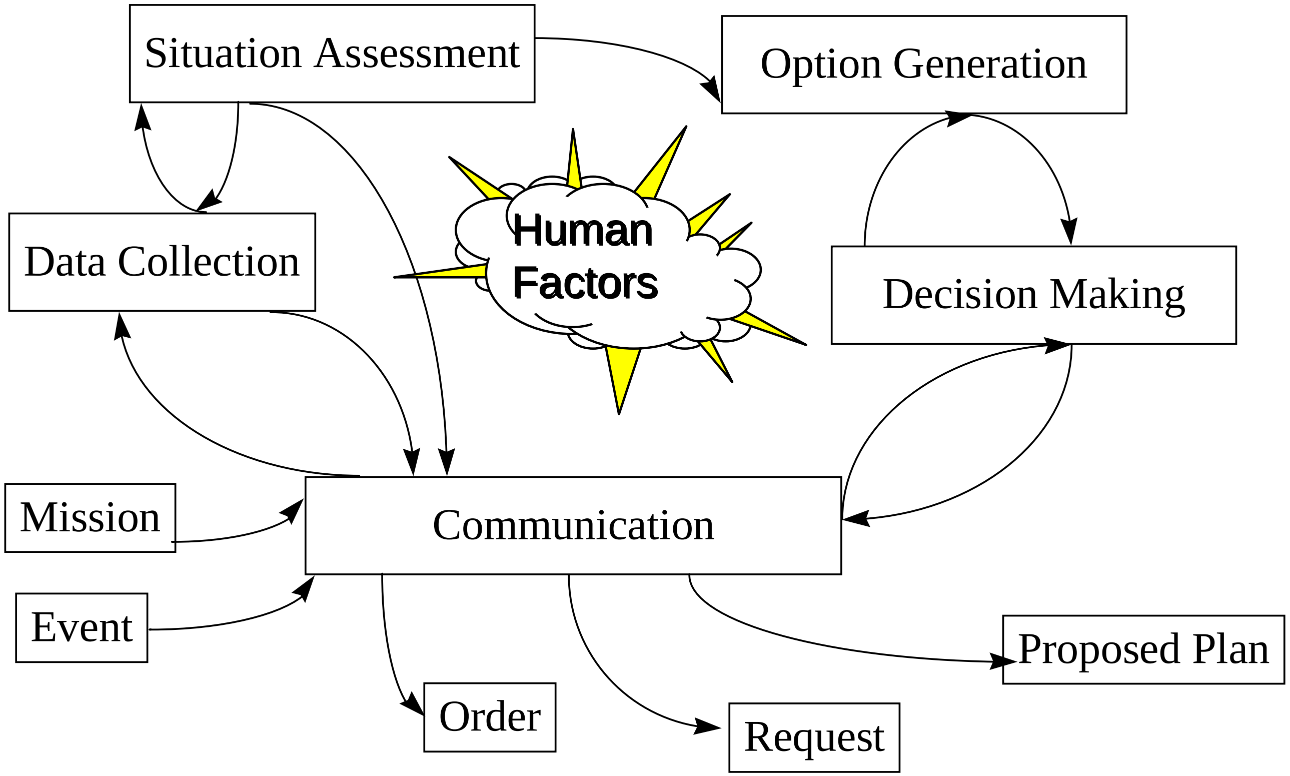
# Simulation System Architecture



## Interoperability Protocol Layers

- The communication layer, which provides the mechanism for the physical transport of messages between the components of the simulation system.
- The "grammar" layer, which provides the words and rules for building the messages.
- The "semantics" layer, which contains the "dictionary" to attribute meaning to and extract meaning from the messages.

# CGFs Modules



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