Man-machine Integration Design & Analysis System (MIDAS)

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Scope/Background

- **Begun in 1984, exploratory development (6.2) program. Focus has been crew station design /procedural analysis. Example questions:**
  - Where are design-induced workload drivers? Does design a/b lead to faster completion of tasks?
  - Is crew station geometry acceptable? Support for accomodation, FOV, glare, lighting, resolution, analyses.
  - How should cockpit information be arranged to facilitate task performance?
  - How do task interruptions, error rates, e.g., propagate to more aggregate measures of effectiveness?

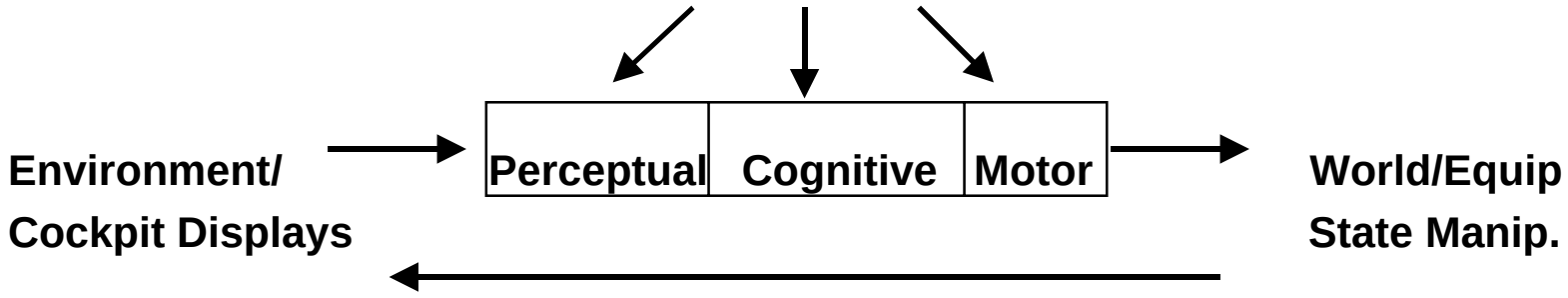
Scope/Background

- **Approach is to combine 3-D graphic prototyping, task analysis methods and embedded human performance models to improve design cycle time.**

- **Characteristics:**
  - Approx 350K LOC, SGI workstation based
  - No non-simulated humans
  - Non-real time, no DIS orientation
  - Previous focus on single operator simulation. Recent expansion to “team” performance, e.g. ATC - Aircrew communication
  - Major architecture/model revisions on-going

Human Behavior Content

- **Human roles/tasks modeled:**
  - Aircrew member (checklist performance, air-ground targeting, decent profile negotiation, Warning/Caution/Advisory processing + subordinate actions)
  - Nuclear Reactor Operator (fault diagnosis, checklist procedure execution)
  - Air Traffic Controller (high/low sector traffic responsibilities)
- ***In general*, behavior is generated by operator task descriptions...** **Hierachical Mission Decomp.**



Human Behavior Content

MIDAS user defines desired behavior through temporal/logical constraint specification of "generic" goal activity types, associated leaf activities, (reach, scan, decide,) specializing and creating new classes/instances as required by equipment/scenario

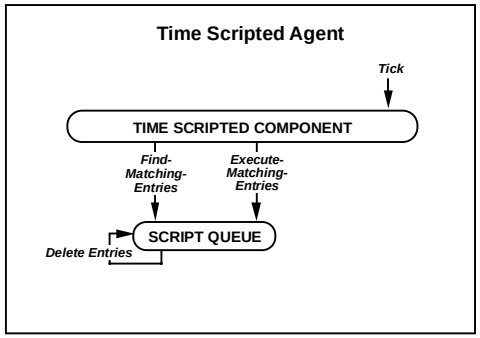
Example Activity Description: Weapons activation

Human Behavior Representation

Similarly, equipment/world models are built-up.....

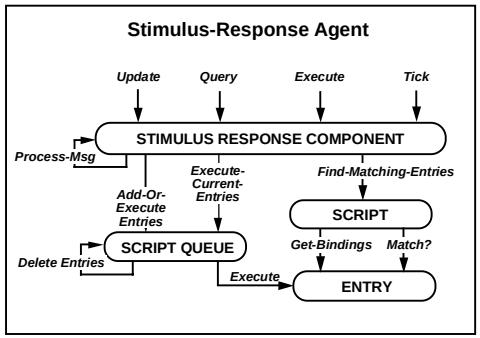
Time-scripted:

- Generates messages at known times, regardless of what else happens in the simulation.
- Used to quickly build initial versions of equipment components.



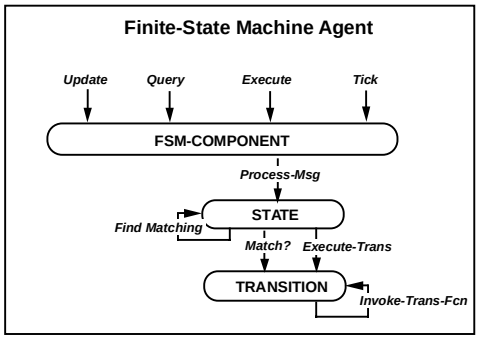
Stimulus-Response:

- Generates output messages in response to input messages (possibly with a delay).
- Used to model components that respond to external events.



Finite State Machine:

- Behavior given by states and transitions between those states.
- Used to model the behavior of a complex equipment component.



...They serve 4 purposes: Maintain state; source of "upload" to Operator memory structure; stimuli for sensory models; drive graphics (animation)

Content of Human Behavior

Basic Implementation Technology...

Present System: Discrete time based simulation. More uniform adoption of production system approach, based on Reactive Action Packages system (Firby, 1991)

Content of Human Behavior

Basic Implementation Technology...

Previous System: Hybrid. Discrete time based simulation. Distributed control with message passing between agents+ production system within several components (Decide-by-Rule, Daemons)

Content of Human Behavior

Representation Basis/Parameterization:

Vision: Modeled as FOV/filter process. Foveal cones (2.5 deg), Peripheral cones (90 deg) each eye, Depth of focus

Visual Attention: Modeled as single “cone”, varying from 3- 15 degrees based on task type. Some attributes “pre-attentive”, (Remmington & Johnston, 1992)

Memory: Semantic Net (Collins, A.M. & Quillian, M. R., 1969)

LT/WM access rates/ visual-spatial/phonological separation (Baddeley, A.D. (1990). Human Memory: Theory and Practice.)

WM decay rate (exponential form, time since creation)

Decisions: Skill, Rule, Knowlegdge-based elements after Rasmussen

Algorithmic form (weighted additive, elimination by aspect, majority of confirming dimensions, etc) after Bettman, Johnson, Payne, 1988

Content of Human Behavior Representation

Representation Basis/Parameterization (cont.):

Motor: Head/eye and hand movement limits/times: G. H. Robinson (1976); Fitts/Card, (from HOS)

Task Loading/Resources- VACP, (McCracken-Aldrich, 1984)

Task Time Distributions/Interrupts/Errors: Empirical studies and SME input

Human vs Simulation State

Perfect knowledge NOT assumed.....

Geometry, equipment knowledge, domain knowledge, perception, and memory constraints all affect simulated operator knowledge. Some user defined; others emergent from the simulation.

Minimal inferencing about enemy/teammate intent.

Have recently introduced notion of “expectations”

Human vs Simulation State

Situation Awareness:

- **Previous System: Pattern match on "tagged" UWR nodes which trigger reactive behavior...**
- **May 97: Quantitative measure of "SA" developed by R. Jay Shively**
- **Dec 97: Context Schema to organize declarative information for comparison to sensed world state-- will aid in "match" RAP methods to goals**

Human vs Simulation State

Affect/Stressors/Cultural Differences--

Not modeled. Have explored use of performance shapping functions (Laughery, Dahl, et al) assuming data generalizable....

Communication--

Not modeled as an auditory process. Buffer approach.....

Dynamic Behavioral Response

- **Reasoning about future is limited…..**
- **Previous System had concept of "Temporal horizon" for scheduling process.**
- **Present System has concept of "expectations".**
- **Command & Control aspects not modeled. Some role/task differences are captured in activity descriptions.....**

Evaluation

- **Strengths--**

  Integrated approach - environment/equipment, human figure, information processing all modeled

  Flexible software structure, range of behavior captured

  Simulated behavior a mix of reactive and goal driven tasks

  Good support for monte carlo/sensitivity analyses

Evaluation

- **Weaknesses--**
  - No continuous control modeling
  - Attention/task loading (VACP) approach limited:
    - Aggregation to higher level difficult, “calculated” rather than a competition for resource process, not sufficiently sensitive to equipment/context
  - Most errors, task performance not an emergent property--(high workload forces shedding/delay of activities, but not degradation of performance)
  - Labor intensive to use.
  - Limited output measures which directly guide design improvement
  - Scale-up to multi-operator system with communication has challenges (comm thrashing example)

Evaluation

Limted Validation to date:

- Most components/parameters have theoretical and or empirical basis...

...but, aggregated behavior has many sources of variability.

One model vs human comparision performed...