This paper presents a select set of slides that will be presented in the tutorial on GASP IV. Complete documentation for GASP IV is currently available (1,2) and does not need to be reproduced in these proceedings.


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**SLIDE 1. AN APPROACH TO SIMULATION MODELING**

**SIMULATION MODEL**

- PERFORMANCE REQUIREMENTS
- STRATEGIC DECISIONS
- DESIGN ALTERNATIVES
- ASSESSMENT ALTERNATIVES

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**SLIDE 2. THE TASKS OF A SIMULATION PROJECT**

Deciding to Simulate
Building a Simulation Model
Writing a Simulation Program
Using the Simulation Program for Problem Resolution

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**SLIDE 3. WHAT DOES GASP IV PROVIDE?**

- Automatic Time Advance
- Event Scheduling and Control
- Continuous Variable Integration with Variable Step Size and User Specified Accuracy Requirements
- Discrete-Continuous Interaction Procedures
- Statistical Data Collection
- Random Deviate Generation
- Program Monitoring and Error Reporting
- Information Storage and Retrieval
- Automatic Statistical Computation and Reporting
- Standardized Simulation Reports
- Tabular and Plotted Histograms
- Automatic Plotting Routines
- Built-in User Flexibility in Output Reports and Other Provided Functions

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**SLIDE 4. ADVANTAGES OF GASP IV**

- Allows Discrete-Continuous Modeling
- FORTRAN Based
- Modular
- Ease of Learning
- Ease of Modifying and Extending
SLIDE 5. BASIC SIMULATION CONCEPTS

System Status Representation
Events
Time Advance Procedures
Data Collection and Analysis

SLIDE 6. COMBINED SIMULATION TERMINOLOGY

Time-Events
State-Events
Time Advance
Discrete-Continuous Interactions
  Discrete Changes in State Variables
  Initiation of Time-Events Based on Values of State Variables
  Changing Equation Forms Based on State- and/or Time-Events

SLIDE 7. TIME-EVENT ILLUSTRATION

ARRIVAL EVENT
TIME BETWEEN ARRIVALS
SERVICE TIME

NEXT ARRIVAL EVENT
NEXT END OF SERVICE EVENT

TIME

SLIDE 8. STATE-EVENT ILLUSTRATION

STATE VARIABLE
TOLERANCE
THRESHOLD

STATE EVENT
TIME

SLIDE 9. TIME ADVANCE PROCEDURE FOR COMBINED SIMULATION

TOLERANCE
STATE VARIABLE
THRESHOLD

STATE EVENT
TIME

TIME BETWEEN ARRIVALS
NEXT ARRIVAL EVENT
CURRENT ARRIVAL
SERVICE TIME
NEXT END OF SERVICE EVENT
SLIDE 10. CATEGORIZATION OF GASP IV SUBPROGRAMS

<table>
<thead>
<tr>
<th>Function</th>
<th>GASP IV Provided</th>
<th>User-written</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time advance and status update</td>
<td>GASP</td>
<td>STATE, SCOND, EVNTS, and specific event subprograms</td>
</tr>
<tr>
<td>Initialization</td>
<td>DATIN, CLEAR, SET</td>
<td>Main program, INTLC</td>
</tr>
<tr>
<td>Data storage and retrieval</td>
<td>FILEM, RMOVE, CANCL, COPY, NPRED, NSUCR, NFIN</td>
<td></td>
</tr>
<tr>
<td>Location of state-events</td>
<td>KROSS</td>
<td></td>
</tr>
<tr>
<td>Monitoring of system simulation</td>
<td>MONTR</td>
<td>UMONT</td>
</tr>
<tr>
<td>Error reporting</td>
<td>ERROR</td>
<td>UERR</td>
</tr>
<tr>
<td>Data collection and reporting</td>
<td>COLCT, TIMST, TIMSA, HISTO, GPLOT, PRNTQ, PRNTS, SUMRY</td>
<td>SSAVE, OTEPUT</td>
</tr>
<tr>
<td>Miscellaneous support</td>
<td>SUMQ, PRODQ, GTABL, GDLAY</td>
<td></td>
</tr>
<tr>
<td>Random deviate generation</td>
<td>DRAND, UNFRM, TRIAG, RNORM, ERLNG, GAMA, RETA, NPSSN, EXPON, WEIBL, DPROB</td>
<td></td>
</tr>
</tbody>
</table>

SLIDE 11. ORGANIZATIONAL STRUCTURE OF A GASP IV PROGRAM

SLIDE 12. ORGANIZATIONAL STRUCTURE BY GASP IV SUBPROGRAM
SLIDE 13. CEDAR BOG LAKE ECOLOGICAL SYSTEM

SLIDE 14. ORGANIZATIONAL STRUCTURE OF GASP IV PROGRAM FOR CEDAR BOG LAKE SIMULATION (CONTINUOUS)

SLIDE 15. DEFINITION OF VARIABLES AND EQUATIONS FOR CEDAR BOG LAKE EXAMPLE

Definition of Variables:

\[ \frac{dSS(1)}{dt} = I = 1.5 \]

System Equations:

\[ SS(6) = 95.9 \times (1 + 0.635 \times \sin(TNOW + 6.28318)) \]
\[ DD(1) = SS(6) - 4.43 \times SS(1) \]
\[ DD(2) = 0.48 \times SS(1) - 17.97 \times SS(2) \]
\[ DD(3) = 4.85 \times SS(2) - 4.65 \times SS(3) \]
\[ DD(4) = 2.55 \times SS(1) + 6.12 \times SS(2) + 1.95 \times SS(3) \]
\[ DD(5) = SS(1) + 6.90 \times SS(2) + 2.70 \times SS(3) \]

with initial values:

\[ SS(1) = 0.83 \quad SS(4) = 0.0 \]
\[ SS(2) = 0.003 \quad SS(5) = 0.0 \]
\[ SS(3) = 0.0001 \]

SLIDE 16. GASP IV PROGRAM FOR CEDAR BOG LAKE -- CONTINUOUS CASE

PROGRAM MAIN

NCRD = 5
NPRNT = 6
CALL GASP
STOP
END

SUBROUTINE INTLC

\[ SS(1) = 0.83 \]
\[ SS(2) = 0.003 \]
\[ SS(3) = 0.0001 \]
\[ SS(4) = 0.0 \]
\[ SS(5) = 0.0 \]
RETURN
END

SUBROUTINE STATE

\[ SS(6) = 95.9 \times (1 + 0.635 \times \sin(TNOW + 6.28318)) \]
\[ DD(1) = SS(6) - 4.43 \times SS(1) \]
\[ DD(2) = 0.48 \times SS(1) - 17.97 \times SS(2) \]
\[ DD(3) = 4.85 \times SS(2) - 4.65 \times SS(3) \]
\[ DD(4) = 2.55 \times SS(1) + 6.12 \times SS(2) + 1.95 \times SS(3) \]
\[ DD(5) = SS(1) + 6.90 \times SS(2) + 2.70 \times SS(3) \]
RETURN
END

SUBROUTINE SSAVE

CALL GPLOT(SS,TNOW,1)
RETURN
END

SLIDE 17. ORGANIZATIONAL STRUCTURE FOR COMBINED GASP IV PROGRAM OF CEDAR BOG LAKE

MAIN

GASP  \rightarrow  DATIN  \rightarrow  INTLC

STATE  \rightarrow  SSAVE  \rightarrow  SUMRY

EVENTS(IX)

IX=1  \rightarrow  IX=2  \rightarrow  IX=3

STOCK  \rightarrow  REPLEN  \rightarrow  SPRAY

Return

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SLIDE 18. GASPI CODE FOR COMBINED VERSION OF CEDAR BOG LAKE

SUBROUTINE EVNTS(IX)
GO TO (1,2,3), IX
1 CALL STOCK
RETURN
2 CALL REPLEN
RETURN
3 CALL SPRAY
RETURN
END

SUBROUTINE STOCK
ATRIB(1) = TNOW + 0.1
CALL FILEM(1)
SS(3) = SS(3) + 0.3
RETURN
END

SUBROUTINE REPLEN
SS(2) = SS(2) + 0.2
RETURN
END

SUBROUTINE SPRAY
ATRIB(1) = TNOW + 0.5
CALL FILEM(1)
SS(1) = .70*SS(1)
RETURN
END

SUBROUTINE SCOND
LFLAG(1) = KROSS(3,0,0,0,0,0.6,1,0.01)
RETURN
END

SLIDE 19. A POST OFFICE QUEUEING SITUATION

SLIDE 20. SUBPROGRAM ORGANIZATION FOR QUEUEING SIMULATION

SLIDE 21. PROGRAM MAIN FOR QUEUEING EXAMPLE

PROGRAM MAIN
NCRD = 5
NPRT = 6
BUS = 0.0
CALL GASP
STOP

SLIDE 22. SUBROUTINE ARRIVAL FOR QUEUEING EXAMPLE

SUBROUTINE ARRIVAL
ATRIB(1) = TNOW + RNORM(1,1)
ATRIB(2) = 1.0
CALL FILEM(1)
ATRIB(3) = TNOW
IF(BUS.EQ.0.0) GO TO 10
CALL FILEM(2)
RETURN
10 WAIT = 0.0
CALL COLEC(WAIT,1)
BUS = 1.0
CALL TIMST(BUS,TNOW,1)
CALL SCHE
RETURN
END

SLIDE 23. SUBROUTINE SCHE FOR QUEUEING EXAMPLE

SUBROUTINE SCHE
ATRIB(1) = TNOW + TRIANG(2,2)
ATRIB(2) = 2.0
CALL FILEM(1)
RETURN
END

SLIDE 24. SUBROUTINE ENDSV FOR QUEUEING EXAMPLE

SUBROUTINE ENDSV
TISYS = TNOW - ATRIB(3)
CALL COLEC(TISYS,2)
IF(NNQ(2).GT.0) GO TO 50
BUS = 0.0
CALL TIMST(BUS,TNOW,1)
RETURN
50 CALL RMOVE(MFE(2),2)
WAIT = TNOW - ATRIB(3)
CALL COLEC(WAIT,1)
CALL SCHE
RETURN
END