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UPDATE ON SDIO'S STRATEGIC SCENE GENERATION MODEL

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ABSTRACT

The Strategic Defense Initiative (SDI) must simulate the detection, acquisition, discrimination and tracking of anticipated targets and predict the effect of natural and man-made background phenomena on optical sensor systems designed to perform these tasks. NRL is developing such a capability using a computerized methodology to provide modeled data in the form of digital realizations of complex, dynamic scenes.

The Strategic Scene Generation Model (SSGM) is designed to integrate state-of-science knowledge, data bases and computerized phenomenological models to simulate strategic engagement scenarios and to support the design, development and test of advanced surveillance systems. Multi-phenomenology scenes are produced from validated codes — thereby serving as a standard against which different SDI concepts and designs can be tested.

This paper describes the SSGM architecture, the software modules and data bases which are used to create scene elements, the synthesis of deterministic and/or stochastic structured scene elements into composite scenes and scene sequences, and the software system to manage the various data bases and digital image libraries. We will also discuss the design architecture and development schedule of the fully-functional Baseline Model (SSGMB) which is currently being implemented.[1]

[1] This work is being performed for NRL by Photon Research Associates (PRA), with subcontractor ... rch Corporation (MRC), Physical Research ... Corporation (TASC), Teledyne Brown Engineering under contract N00014-89-C-2283.

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1.0 INTRODUCTION

NRL has been given the responsibility by the Technology Directorate of SDIO for developing the Strategic Scene Generation Model (SSGM) to provide modeled data in the form of digital realizations of complex multi-phenomenology scenes. The SSGM project supports SDIO R&D technology demonstrations and measurements programs (see Table 1) by furnishing valid pre-computed scenes and dynamic scene sequences for specific engagement scenarios and/or the software capability to generate these scenes.

TABLE 1. CURRENT SSGM USER COMMUNITY

PROGRAM	AGENCY	SSGM APPLICATION
BSTS (AWS)	SSD	Standard fixed-frame SWIR & MWIR scenes for hardware demonstrations, digital simulations, and evaluation of system performance predictions (SN)
SSTS (BE)	SSD	Midcourse LWIR scenes to support system demonstration and validation methodology (SN)
GSTS	ASDC	LWIR scenes to support integrated ground testing of early attack characterization and precommit for midcourse (SN)
KHILS	AFATL	SSGM software to meet scene data base generation requirements for the Target Scene Generator (KE)
IATACS	WL	Dynamic scenes for the Integrated Acquisition, Tracking and Aimpoint Control System (DE)
DWSG	AEDC	SSGM scenes to support technical development of the Direct-Write Scene Generator which uses acousto-optical devices to stimulate focal plane detectors (SN)
NTB	SDIO	SSGM software to support NTF system evaluations and simulations, calibration/authentication of engagement level models (TB)
STB	SDIO-SEI	SSGM software to support Surveilance Test Bed for detailed simulation, digital emulation and performance analysis of SDS surveillance elements (TB/SN)
AMDF	RADC	SSGM software to generate scene data bases for the Attack Management Development Facility (TB/DE)

SN = Surveillance Sensor, KE = Kinetic Energy, DE = Directed Energy, TB = Test Bed

SSGM products are used to evolve system concepts into preliminary designs, critical designs, and eventually performance test. For example, custom scenes have been created for candidate BSTS (now AWS) sensors and for specific viewing geometries to provide a basis for comparing performance predictions of the two prime contractors (LMSC & GAC). Likewise, SSTS (now BE) and GSTS programs have indicated that they require precomputed scenes tailored to their specific requirements. These surveillance tracking systems also require fully operational SSGM software and supporting input data bases to generate end-to-end scene sequences for testing target handover and sensor fusion. The SSGM program currently supports several hardware-in-the-loop system simulations of kinetic and directed energy weapons and sensors by providing prototype software and data bases needed by users to specify and generate digital images easily and rapidly (KHILS/TSG, IATACS & DWSG). These tests include ground demonstrations and simulations wherein scaled sensors perceive and respond to real photometric data generated from digital images produced by the SSGM. Signal injection or in-band scene projection technology are used in these hardware-in-the-loop simulations which will eventually be event-driven. User-generated scenes are also used to populate large data bases required by system test beds and development facilities for exercising and refining algorithms used in target acquisition, aimpoint control and defensive attack management; and digital emulation and performance analysis (NTB/NTF, STB & AMDF).

The SSGM is being developed to integrate, for the first time, the various "government-standard" phenomenology codes to provide valid, standard scene data to a community of users. Traditionally, individual phenomenology models allow the user to estimate the nature and importance of observables when it is infeasible to sample all required spatial or temporal resolutions, viewing aspects, or wavelengths. The SSGM is a critical capability which combines various first principles and semi-empirical codes and data bases into an architecture specific to anticipated SDIO application requirements. Where appropriate, the SSGM makes direct use of existing data archived in one of three Phenomenology Data Centers being developed by the SDIO.[2] This interface will facilitate the validation of SSGM methodology by providing direct access to the relevant empirical data.

The SSGM development will occur in three phases (see Table 2), the first of which has been completed. These are: SSGM Prototype, SSGM Baseline, and SSGM Operational. The Prototype (SSGMP) was delivered to NRL, is being utilized by selected government agencies and

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[2] Midcourse Data Center at ASDC in Huntsville, Background Data Center at NRL in Washington, and Plume Data Center at AEDC in Tullahoma.

TABLE 2. LONG-TERM SSGM DEVELOPMENT & IMPLEMENTATION SCHEDULE

SSGM PHASE	COMPLETION DATE	MAJOR DELIVERABLES	CHARACTERISTICS & CAPABILITIES
SSGMP	2/89	• Design/Build **Prototype SSGM** • Design Baseline SSGM • Documentation & Manuals	• Background Phenomenologies below Troposphere on-line • 2.7, 4.3, 10-14 μm Bands • FORTRAN-77, UNIX & VMS
SSGMB	9/92	• Code/Build **Baseline SSGM** • Four Releases (V1.0 thru V4.0) • Develop/Update Data Bases • Optimize Code for Parallel Processing • Implement Configuration Management • Implement Independent Verification & Validation Contract • Documentation & Manuals	• Planned Evolutionary Development • Fully Functional SSGM • All Phenomenologies on-line • Event-Driven Capability • Responsive to User Requirements • Limited Set of Data Bases • Dynamic, Window/Menu User Interface • FORTRAN-77, "C", UNIX
SSGMO	9/94	• Code/Build **Operational SSGM** • Maintain Baseline SSGM • Specialized Hardware	• Near Real-Time Capability • Spanning Set of Data Bases • Updated Phenomenology Codes
SSGM	------	• Maintenance Phase • Configuration Management	• Updated Phenomenology Codes • Expanded Set of Data Bases

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laboratories, and serves as the foundation for the SSGM Baseline development. The SSGM Baseline is planned for final delivery in September 1992. Architecturally, it will be fully responsive to SDIO needs, but will have data base and execution speed limitations. The SSGM Operational model will have a full complement of data bases and achieve execution speeds adequate to support real-near-time hardware-in-the-loop simulations.

An evolutionary approach has been adopted for the SSGM Baseline whose development is in progress. The first release (SSGMB V1.0) was made just prior to this conference (September 1990) and is now available to the user community as a code still in development but under formal configuration management. Since the full functionality of the SSGMP has been retained, the SSGMP will no longer be maintained. As a prerequisite to obtaining the SSGMB, users must complete a 2-1/2 day class which offers instruction on SSGM capabilities, current limitations and hands-on experience via computer workstation. Three additional software releases of the evolving SSGMB are planned at roughly eight month intervals. A SSGM users group is being formed to serve as a forum to discuss user requirements and suggested improvements and also to introduce new SSGMB releases to the community.

2.0 SSGM REQUIREMENTS

The scene data needed to support SDIO program elements consists of radiometrics of scene elements plus time-sequenced 2-D scenes of sensor-perspective pixel radiance maps of backgrounds with imbedded targets. The SSGM must represent user-specified scenarios of strategic significance. For example, a satellite-borne surveillance, acquisition, or track sensor may view a boosting missile positioned against an earth horizon background. The specific composition of this scene is constantly changing because the sensor and target are moving along their trajectories, there is drift and jitter in the sensor line-of-sight, and the missile plume emission is itself varying with time.

For general sensor-target-background engagement scenarios, various target and background observables could exist within the scene sequence. Phenomenology associated with targets might consist of the missile hard body, missile plume and target related persistence phenomena (fuel dumps), spent stages, satellites, post-boost vehicles, re-entry vehicles, decoys, penetration aids, and post-kill debris (including salvage-fused warheads). Backgrounds might include "hard" earth (terrain, ocean, and ocean ice), meteorological phenomena (semi-transparent/opaque clouds), quiescent atmospheric phenomena (scattering/emission/absorption, earth-limb airglow emission), the perturbed atmosphere (aurora and man-made backgrounds including single or multiple nuclear detonations), and celestial sources (zodiacal, galactic, and extragalactic).

The problem confronting the SSGM is to provide such digital scene sequences constrained only by limitations in the physical models and empirical data bases incorporated within on-line phenomenology codes and/or pre-computed data bases. The goal is to encompass the totality of spatial, temporal, and spectral sampling regimes set by anticipated SDI sensor system specifications and engagement scenarios. The frame size may range from a few hundred to over several thousand pixels in each dimension and the duration of the scenario may span a hundred or more seconds at a fraction of a second framing rate. The size of the digital scene data base produced may range from several tens to several thousands of megabytes and, when coupled with event-driven simulations, must be produced in reasonable times by a software architecture which is responsive to the external interrupts implicit when unforseen events influence the flow of the simulation. The dynamic range, spectral range, and resolution must also span likely sensor candidates. However, the SSGM does not attempt to model optical or sensor systems which modulate the calculated scene radiance values.

3.0 SSGM ARCHITECTURE

Viewer-perspective digital radiance maps, or scenes, are derived from an ensemble of the best available government standard phenomenology models and authenticated data bases via an interactive software system which selects the required input parameters and executes the pertinent models to generate the scenes specified by the user (see Figure 1).

The SSGM process consists of three major functions (Scenario Specification, Run-Time Generation, and Frame Generation) interfacing with four data base libraries (Scenario, Element, Run-Time, and Digital Scene). The SSGM is also supported by a Scenario Construction Tool (SCT) which serves as an interactive, but independent, user interface. The SCT and the four primary SSGM software modules which accomplish these functions will be described below. Additional tools for display and rudimentary analysis of SSGM generated scenes and scene sequences are packaged with the SSGM software to provide a complete capability to script, generate and inspect composite multiphenomenology scenes.

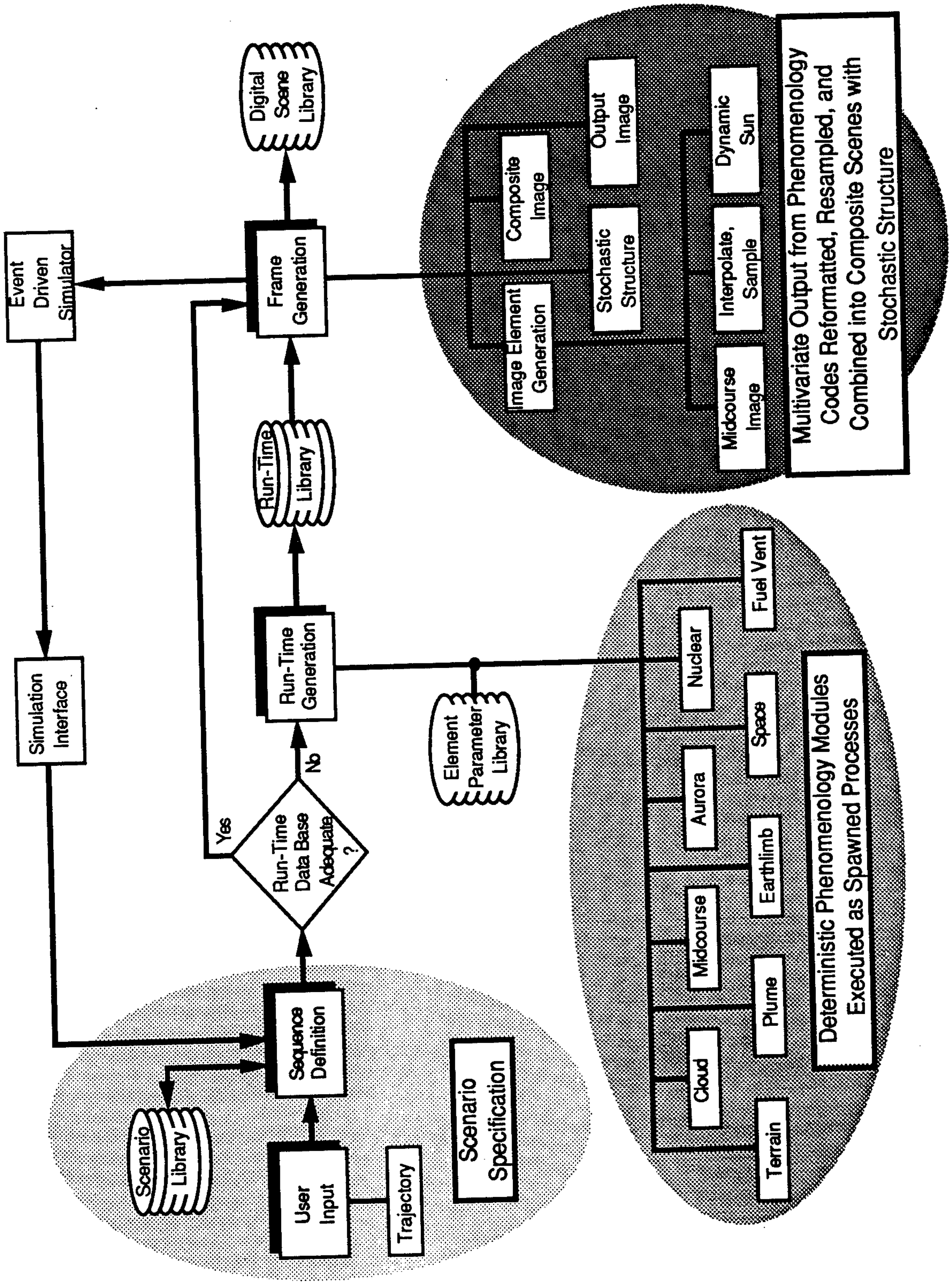

Figure 1. SSGM Baseline Functional Flow Diagram

Scenario Construction Tool (SCT) has been implemented on the family of Silicon Graphics workstations (using the SGI 4Sight windowing environment). The SCT enables the user to actually "build" a scenario interactively through the window menu interface which supports X11, NeWS and GL clients simultaneously. SCT functionality includes: invoking sensor and target trajectory computations, computing sensor-target background engagement geometries, displaying graphical sensor FOV representations and views from the perspective of any number of independent "meta-observers", and creating and updating SSGM Scenario Definition Files through menu selections and terminal inputs. The SCT was designed to aid preparation and specification of the scenario parameters by means of dynamic 3D graphics and visual feedback.

User Input accepts all sensor, background, and target input specifications from the Scenario Definition File (generated either by the SCT or by a user-developed off-line process). User Input transforms this "script" into a format acceptable for subsequent input to the Sequence Definition Module but also invokes certain options pertaining to the SSGM Data Base Management System (DBMS). These include adding and deleting items stored in the data base libraries and reporting information on these items.

Sequence Definition interprets the scene requirements, computes sensor-target-background engagement geometries, and calculates scene sampling parameters in the context of the specified scenario. The geometric boundaries of the scenario are computed and the associated bounding elements required to perform the scene generation for the defined scenario are determined and stored in the Scenario Library. Specifically, for each pixel of the sensor FOV, its location versus time is quantified, as well as the composition of the scene it views. Once the boundaries have been established, Sequence Definition determines whether or not the elements currently exist in the Run-time Library or need to be generated.

Run-Time Generation, supported by nine subfunctions, calculates all additional data needed to generate the scenes defined by Sequence Definition. This is achieved through on-line execution of phenomenology software modules and is only invoked when deficiencies in the Run-Time Library data base are established during Sequence Definition. Inputs to the phenomenology modules are derived from the frame requirements stored in the Scenario Library. Also, the Element Parameter Library contains specific data bases required by the individual phenomenology submodules (*e.g.*, atmospheric chemistry data, materials properties, bidirectional reflectivity functions, *etc.*). The multivariate output from the phenomenology codes populate the Run-Time Library which can be accessed quickly during the process of Frame Generation.

Frame Generation casts Run-Time Library files into image elements (termed "chips") which can be spatially and temporally resampled and combined to synthesize composite, multi-phenomenology scenes. Four submodules (Image Element Generation, Stochastic Structure, Composite Image, and Output Image) convert the Run-Time Library data bases into viewer-perspective two-dimensional pixel images. Typically, this involves interpolating and sampling, but can also involve image generation for hardbody targets, for targets or missile plumes which are being actively illuminated by lasers, and for terrain or cloud backgrounds when they are being illuminated by a "dynamic" sun (*i.e.*, nuclear fireball or missile plume). When the statistics of a random process can be specified from empirical data, the structure of deterministically computed image elements can be modulated independently to simulate the stochastic process. "Deterministic structure" refers to spatial variation in radiance which can be specifically computed from the physics models involved. "Stochastic structure" refers to irregularities in the target or background which cannot be predicted in a deterministic manner, but for which statistics can be generated. The mathematical and computation techniques used to generate stochastic representations of different types of structure are similar, regardless of whether the phenomenon is the ambient atmosphere, the auroral-disturbed atmosphere, the nuclear-perturbed atmosphere, or a missile plume. Thus, the SSGM design uses a single structure generation code for all of these environments. The basic procedure generates a gaussian noise image with zero mean and unit variance. This image is then filtered with a two-dimensional power spectral density function representing the stochastic structure, multiplied by a variance image and added to the the deterministically structured image to produce the final result. The time-sequenced deterministically or stochastically computed radiance maps for individual scene elements are then assembled into composite, full field-of-view images in the Composite Image Module. Following Frame Generation, the composite scenes are stored as files in the Digital Scene Library where they can be analyzed and displayed. The Frame Generation Module also accomplishes the preparation of metric and radiometric summary files and computes a report of radiance statistics for each frame.

When a user's purpose is to generate input data bases for testing sensor or system models or for use in actual hardware simulations, certain features or events in a scene may trigger changes in the definition of subsequent frames. The SSGM contains a Simulation Interface Module which effects the event-driven feedback process when dealing with possible, but temporally unpredictable, events. This module performs a scene diagnostic test to alter subsequent scene generation in accordance with preassigned decision logic. Typically, the feedback loop would only interface with Frame Generation but could require Run-Time Generation to create new Run-Time Library data.

4.0 SSGM PHENOMENOLOGY

The phenomenology consists of quiescent and enhanced natural backgrounds and perturbed backgrounds with imbedded targets and target induced or related events. Endorsed and validated predictive models for these phenomena continue to be developed and refined by government agencies (GL, AL, ASDC, NRL, DNA, NASA, *etc.*) which are also responsible for code verification, validation, and configuration management. NRL rehosts these standard codes, or output data bases generated off-line, within the SSGM architecture and verifies that the composite scenes are accurate renditions as specified by the input scenario.

Tables 3 and 4 list candidate codes which are likely to be incorporated in the SSGM architecture. Several of these codes, specifically NORSE for nuclear effects and OSC for hard-body target signatures, are so large or computationally intensive that it is impractical to host them within the SSGM. In these cases, the codes are run off-line to generate data bases which are stored in the Element Parameter or Run-Time Libraries and subsequently accessed by more manageable codes incorporated within the SSGM. For example, the engagement level nuclear codes PEM and IRSim use NORSE output data bases. Similarly, the SIGNAT interpolation code operates on the GSTS point-source data base for unresolved midcourse object signatures. Both the code and data base are traceable to the OSC.

The SSGM will integrate, for the first time, strategically relevant phenomenology codes which differ in origin and level of sophistication, into a common architecture. Since SSGM requirements pertain only to the generation of strategic scenes, in some cases it is sufficient to incorporate specific submodules of larger codes (such is the case for midcourse signatures). In other cases the existing codes are currently very research-oriented and require a good deal of "hand tailoring" to achieve acceptable results. This is the case for certain aspects of missile plume phenomenology. Hence, SPF2 will be used off-line to generate data bases for input into SIRRM which will be an on-line code. A major technical challenge is that the SSGM must simultaneously address configuration management issues relating to SSGM maintenance, augmentation, and traceability in an environment where the fundamental codes themselves are undergoing development.

The SSGM, in general, does not presume to model physical interaction between individual phenomenologies beyond that which is incorporated within the standard models themselves. For example, cloud phenomenology, characterized by radiance and transmission maps produced by

TABLE 3. CANDIDATE SSGM PHENOMENOLOGY MODELS (MAN-MADE ELEMENTS)

CATEGORY/ OBSERVABLE	MODEL	DESCRIPTION	GOV. AGENCY/ DEVELOPER
TARGET			
Missile Plume	SIRRM III	Plume Radiance for 2D/3D Geometries (.7-25 microns, <50 km)	AL/MICOM, GAC, SSI
Missile Plume	SPF2	Couples Missile Body, Base & Plume Flowfield (<70 km)	AL/MICOM, PST, Plumetech
Missile Plume	CHARM 1.3	Plume Flowfield & Radiance (.7-25 microns, >70 km)	AL/LMSC,SSI,AOI, CALSPAN, GAC
Missile Plume	SPURC	Plume Flowfield & Radiance (.1-.7 microns, >0 km)	AL/GAC, AOI, SSI, PSI
Plume Transients	SFM	Flowfield & Transients (staging, chuffing, thrust vector control)	AL/SEA, AOI, JAYCOR
Plume Illumination	HALT	Plume/Laser Retroreflectance	AL
Fuel Release	FRES	Fuelvent/Oxidizer Dynamics code (FUELVENT) combined with Radiance code (HIACRES)	AL/LMSC, PRA, Aerospace
Target Hard Body	OSC (XVI)	Optical Signatures Code	ASDC/TBE
Target Hard Body	FASTSIG	Exoatmospheric, fast OSC-like code	ASDC/TBE
Target Hard Body	SIGNAT & INTEG	GSTS Point Source Data Base with supporting Interpolation & Integration	ASDC/TBE
Target Illumination	DELTAS	Target/Laser Retroreflectance	SDIO/NRC
NUCLEAR			
Perturbed Limb	NORSE	Analytic Application Code (Rad.)	DNA/PRi, MRC
Perturbed Limb	PEM	Engagement Code (Rad.)	DNA/ASDC/PRi
Perturbed Limb	IRSim	Engagement Code (Rad.)	DNA/PRi
Perturbed Limb	HiSEMM	Engagement Code (Rad. & RF Prop.)	DNA/PRi

CLDSIM, is simply overlaid onto terrain phenomenology from GENESSIS during Frame Generation such that there is no current SSGM capability to represent cloud shadows on terrain. However, the SSGM architecture could easily accommodate such a capability if an SDI requirement were to be identified. In fact, some limited interaction of phenomena has been incorporated within the SSGM when believed to be a significant concern to known systems. Such is the case for low-altitude, early-time nuclear fireballs which illuminate terrain and clouds. Similarly, high-altitude nuclear detonations may effectively elevate earthlimb, auroral and plume radiances by modifying atmospheric density, a phenomenon known as nuclear heave. Hence, a "dynamic sun" capability has been included during Frame Generation to treat nuclear burst and missile plume irradiance of terrestrial backgrounds, and the Earthlimb, Aurora and Plume modules will have access to atmospheric state data from the Nuclear module.

TABLE 4. CANDIDATE SSGM PHENOMENOLOGY MODELS (NATURAL ELEMENTS)

CATEGORY/ OBSERVABLE	MODEL	DESCRIPTION	GOV. AGENCY/ DEVELOPER
TERRESTRIAL			
Hard Earth	GENESSIS	Terrain Scenes (Rad.)	DARPA/NRL/PRA
Cloud	CLDSIM	Cloud Scenes (Rad. & Trans.)	NRL/PRA
EARTHLIMB			
LTE Atmosphere	LOWTRAN	LTE Band Model (Trans. & Rad.)	GL
LTE Atmosphere	APART	Propagation and Radiative Transport	PRA
LTE Atmosphere	MODTRAN	LTE Band Model (Trans. & Rad.)	GL
LTE Atmosphere	FASCODE	LTE Line-by-Line (Trans. & Rad.)	GL
NLTE Atmosphere	FASCODE	NLTE Line-by-Line (Rad.)	GL
NLTE Limb	HAIRM	NLTE Line-by-Line (Rad.)	GL/Visidyne
NLTE Limb	ARCHON	Atmospheric Chemistry Code & Database	DNA/MRC
NLTE Limb	ARC	NLTE (Rad.)	GL
NLTE Limb	SHARC	NLTE (Rad.)	GL
AURORA			
Perturbed Limb	ARCTIC	Aurora (Rad.)	MRC
Perturbed Limb	AARC	Aurora (Rad.)	GL
SPACE			
Celestial Phenomena	CBSD	Zodiacal, Planetary/Interplanetary Objects, Galactic/Extragalactic Point Sources, Diffuse/Structured Backgrounds	GL/MRC

For further information on SSGM phenomenology, the reader is referred to a series of papers published in the unclassified proceedings of the January 1990 meeting of the IRIS Speciality Group on Targets, Backgrounds and Discrimination (see Table 5 and References). The paper by Heckathorn and Anding describes SSGM treatments for celestial background phenomenology which is based heavily on the products of the GL's Celestial Background Scene Descriptor (CBSD) program. Three additional papers by members of the SSGM development team describe SSGM treatments for other background and target phenomenologies and for handling spatial and temporal structure. Anding, Mertz and Fleri describe terrestrial backgrounds, missile plumes, and midcourse objects. Armstrong, McKenzie and Saunders discuss the SSGM approach being developed for earthlimb and aurora phenomenologies, including treatments for stochastic structure. Blackwell, Stephens, Gomez and Teoh describe how structured infrared backgrounds created by nuclear detonations are represented in the SSGM. They also describe how

TABLE 5. SSGM PUBLICATIONS FROM JANUARY 1990 IRIS/TBD MEETING

AUTHORS & AFFILIATION	TITLE, CONTENT & PHENOMENOLOGY MODELS
Heckathorn & Anding (NRL & PRA)	"Overview of the Strategic Scene Generation Model (SSGM)" SSGM Program Description, Requirements, Architecture, Phenomenology, Celestial Backgrounds **Models:** CBSD, SKY, ZODY
Anding, Mertz & Fleri (PRA)	"Background & Target Plume Models for the Strategic Scene Generation Model" Terrestrial Background (Terrain & Cloud), Missile Plumes, Midcourse Objects, and SSGM Frame Generation Software **Models:** GENESSIS, CLDSIM, APART, SPF2, SIRRM, CHARM, OSC, SIGNAT, INTEG
Armstrong, McKenzie & Saunders (MRC)	"Earthlimb and Aurora Background Scene Generation" Natural LTE & NLTE Atmospheric Radiance, Deterministic/Stochastic Structure, and SSGM Earthlimb/Aurora Submodules **Models:** LOWTRAN, APART, HAIRM, ARCHON, SHARC, NLTE, ARCTIC
Blackwell, Stephens, Gomez & Teoh (PRi)	"Nuclear Backgrounds for SSGM" IR Nuclear Backgrounds, Temporally Correlated Stochastic Structure and SSGM Nuclear Submodule & Data Bases **Models:** NORSE, PEM, IRSim, STRCTR

a DNA-produced structure module, which modulates deterministically computed scene elements to produce small scale temporally correlated spatial structure, has been incorporated into the SSGM. For further information on the SSGM program, the reader is referred to Anding *et al.* (1988) and Heckathorn *et al.* (1988). The Baseline SSGM design is described by Anding (1988b) and additional aspects of the software development are discussed by Franklin *et al.* (1990).

5.0 SSGM BASELINE DEVELOPMENT & SCHEDULE

An evolutionary, multi-phase approach is being taken for SSGM Baseline development since the program must provide interim capabilities to meet immediate SDI requirements. The computer architecture has been designed and is being developed to be fully responsive to long term needs; however, the supporting data bases on targets and backgrounds are addressing near term needs and will be limited in the Baseline. The Prototype development tested this model architecture, several in-line software modules and representative data bases to create scene elements, the system to manage the various data bases and libraries, and the verification and validation methodology which is based on comparison with empirical data. A detailed description of SSGMP design and functionality is given by Anding (1988a, 1989a, 1989b).

The SSGM Baseline retains Prototype functionality but with somewhat modified architecture and significant additional capabilities required by GSTS and STB. The model has been hosted on the SGI workstation and its use is enhanced by the Scenario Construction Tool which provides an interactive interface for graphical display and modification of scenarios and sensor-target-background engagement geometries. Trajectories may be computed on-line for sensors (orbital vehicles or ballistic probes) and ballistic targets via specification of orbital parameters or initial state vectors as appropriate. These trajectory capabilities are in addition to those in the Prototype which were specified by off-line-generated Dynamics Files. Upgrades to the phenomenology codes for SSGMB V1.0 are extensive (see Table 6) and emphasize targets and backgrounds for midcourse scenarios. Additional functionality, including upgrades to the DBMS and to the software modules (discussed in §3) will be included in subsequent releases. Tables 7 & 8 list phenomenology enhancements scheduled for SSGMB V2.0 & V3.0.

An important limitation of the SSGM Baseline is the speed with which scenes can be generated on conventional parallel processing computers. It is anticipated that for those applications which involve the rapid generation of sequential scenes, the Run-Time Library will be populated by prior executions of the phenomenology submodules. However, for large or complex scenes (those with many objects) the computer time may still be too long to meet the needs of end-to-end simulation systems, particularly real-time hardware-in-the-loop. This limitation will be overcome during the Phase III Operational model development.

TABLE 6. SSGMB V1.0 PHENOMENOLOGY UPGRADES
(15-SEP-90)

OBSERVABLE	REFINEMENT
Terrain	• Refined GENESSIS on-line code plus 3 additional data bases for ocean, sea ice, tundra (30 m resolution, 30x150 km extent)
Clouds & LTE Atmosphere	• Refined CLDSIM & APART on-line codes plus 3 additional data bases (30 m resolution, 30x150 km extent for altocumulus and cumulonimbus; 400 m resolution, 400x400 km extent for an additional altocumulus)
Aurora	• Additional auroral data bases (2 multiple arc in both SWIR and MWIR; Class III arc in SWIR, MWIR, LWIR)
Celestial	• Galactic Point Source code on-line (7-22μm) including band-to-band registration of stellar spatial positions • Diffuse and Structured Zodiacal code on-line (1-30 μm) • User-specified square bands (will treat spectral response functions in SSGMB V1.2) • Output images generated at 100 μradians resolution (will treat user-specified resolutions in V1.2)
Midcourse Target	• GSTS data base for CONUS defense at summer noon uses FASTSIG-generated optical signatures for minimum energy trajectory small and medium RV's, replicas and scaleable balloons each with three possible material types and two sizes (yielding a total of 18 target types) • User-specified square bands from 3-30 μm (will treat spectral response functions in V1.2 using INTEG2) • On-line interpolation software (SIGNAT2) represents intensity as continuous function of time and aspect

6.0 SUMMARY AND CONCLUSIONS

The SSGM is a computerized methodology founded on state-of-science knowledge, empirical data bases, and phenomenological models to generate LOS radiometrics, 2D radiance maps, time-sequenced scenes, and observable data bases for SDI applications. SSGM requirements include SDI-relevant treatments for (1) targets, target-related events, natural and nuclear backgrounds (phenomenology); (2) vehicle types and trajectory phases (scenarios); (3) sensor-target-background locations and time-history sequences (geometries); and (4) spatial, temporal, spectral samplings (dimensions).

TABLE 7. SSGMB V2.0 PHENOMENOLOGY UPGRADES
(15-APR-91)

OBSERVABLE	REFINEMENT
Earthlimb	• On-line calculation of 2D images for defined atmospheric state and user-specified , spatial resolution, extent and square waveband (2-30μm)
Aurora	• On-line calculation of 2D images for user-specified time after initiation, spatial resolution, extent and square waveband (2-30μm)
Celestial	• On-line radiance models for solar system objects (sun, moon, planets, asteroids, comet dust trails). Ephemeris based positions for major objects, statistical treatments for numerous minor objects. • Upgraded zodiacal emission code, extension of point source model to cover 2-30 μm
Nuclear	• On-line calculation of 2D images for user-specified times after burst, spatial resolution and extent • NORSE data bases for extended plasma, beta-tube/patch, massive multiburst • Improved treatment for structure including band-to-band correlation & multiple structure screens
Plume	• On-line calculation of scenario independent axisymmetric plume data bases (CHARM 1.3 with zero angle of attack restriction) for user-specified missiles & trajectories
Midcourse Target	• GSTS data base for the USAKA scenario (WTR launch into the Kwajalein Atoll) using FASTSIG-generated optical signatures for representative midcourse objects (to be included in V2.1).

The two primary near-term tasks of the SSGM project are the evolutionary development of the Baseline SSGM and support for SDIO R&D program elements by furnishing pre-computed scenes and dynamic scene sequences for specific engagement scenarios and/or the software capability to generate scenes. The scenes are physically valid and serve as a standard for testing different SDI concepts and designs. Basically software in nature, the technical challenges include (1) integration of phenomenology codes which differ in origin and purpose; (2) verification and validation of SSGM methodology and multiphenomenology output scenes; (3) the computational burden for creating and resampling image and other multi-dimensional data bases in real time; and (4) requirements for event-driven scenarios, interaction of scene elements, and active illumination.

TABLE 8. SSGMB V3.0 PHENOMENOLOGY UPGRADES
(15-JAN-92)

OBSERVABLE	REFINEMENT
Clouds & LTE Atmosphere	• On-line treatment for curved earth extending to horizon and into earthlimb • Ocean, polar, Soviet cloud data bases developed for BSTS (400 m resolution, 1600x1600 km extent)
Earthlimb	• Rendering of 2D images from on-line calculation of scenario specific variable-grid LOS radiance maps • User-specified square bands (2-30μm) at any spatial resolution (will treat spectral response functions in V3.1) • Latitudinal variation for large scenes, day/night terminator
Aurora	• Treatment for nuclear illumination of aurora • Updated data bases to include additional 3D arc geometry and 1D atmospheric profiles
Celestial	• On-line CBSD phenomenology models to treat extended extragalactic sources, IR cirrus, H II regions and nebulae
Nuclear	• Rendering of 2D images from on-line calculation of scenario specific variable-grid LOS radiance maps at user-selectable times after burst • User-specified square bands (2-30μm) at any spatial resolution (will treat spectral response functions in V3.1) • Extensive NORSE-derived data base • Treatments for nuclear heave and terrain/cloud/plume illumination
Plume	• Rendering of 2D images from on-line calculation of scenario specific non-axisymmetric variable-grid LOS radiance maps as a function of time with full CHARM 1.3 capability
Fuel Vent	• Rendering of 2D images from scenario specific variable-grid LOS radiance maps as a function of time • Treatment will include solar and earthshine scattering, plus chemiluminescence
Midcourse Target	• On-line calculation of spatially resolved and unresolved image signatures including facet geometry, surface reflectance, and temperature

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