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A Standardized and Modular Object Model for Medical Modeling and Simulation for Distributed Training

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A Standardized and Modular Object Model for Medical Modeling and Simulation for Distributed Training

Purpose:

This presentation will describe work done to-date in developing a standardized, modular, data object model to support simulation-based training of medical personnel. The background need, related contract work, and likely continuing work are described.

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Benefits:

- A standardized foundation on which diverse real and simulated systems interact
- Reduced costs and risks to develop and maintain training systems
- A standard data model for use in contract specifications (technical requirements) to procure training systems that are *“interoperable by design”*

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Key Take-Aways:

- A Medical Modeling & Simulation Federation Object Model (MMS FOM) is being built under contract to a US Government agency
  - Initial delivery in Summer 2019
  - Continued future use and expansion will be pursued
- MMS FOM is used with IEEE-standard High Level Architecture (HLA)
- MMS FOM will support standalone & distributed training systems

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Background:

- To date, simulation as a technology applied to medical training has largely meant standalone systems such as:
  - Mannequins to simulate human bodies (patients),
  - Virtual reality to simulate surgery, and
  - Scenario-driven training activities.
- Simulation-based <u>medical</u> training based on distributed training involving many different systems is emerging.
- The history of distributed simulation-based training in other domains, e.g. training pilots in flight simulators, clearly shows that the use of international standards and a standardized data object model is a good way to go forward.

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Background:

- The project is part of a contract issued in 2017 by the Medical Technology Enterprise Consortium (MTEC) and sponsored by the US Government's Medical Simulation and Information Sciences Research Program (JPC-1).
- Development of the MMS FOM is a requirement of that contract.
- The project objective is to provide a training environment that simulates patient care, evacuation, and hand-offs to replicate the continuum of care to improve patient outcomes.
- Continuum of care spans care for combat-injured soldiers at the Point of Injury through higher tiered medical facilities.
- IVIR Inc. (USA) is the prime contractor for the FOM portion of the contract. Subcontractors are: Pitch Technologies (Sweden & USA), EMS (USA), SCM Globe (USA), Discovery Machine (USA), VCom3D (USA) and HC Simulation (USA).

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Benefits:

- 30+ years of simulation-based training experience has shown that simulators and training devices built on standards can:
  - Be the most cost-effective
  - Save much money over time as changes are inevitably needed
  - Implement updates and adaptations faster
  - Enable “Systems of Systems” for more complex training
  - Allow future growth while preserving the value of legacy systems
  - Avoid “stove-piped” (“dead-end”) implementations
  - Enable effective After Action Reviews, plus analysis and reuse of data
  - Train complex scenarios in real time, or slower or faster than real time

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Patient Documentation:

- The trail of documents from combat medic to field hospital to regional hospital to major medical facility, including MEDEVAC transport, must be supported in a training system involving handoffs of patients through those tiers of medical care.
- The MMS FOM defines data exchanges for patient and medical info that was first noted on or later transcribed to paper documents

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Existing Policies and Documents:

- The US DoD, like other similar organizations, has carefully defined policies and procedures for patient care during handoffs from one tier to a higher tier.
- Example, at the Point of Injury, a US Army combat medic uses a Tactical Combat Casualty Care document (TCCC card) to document patient injuries and treatments.
  - Information on the TCCC card is communicated to the next tier medical caregiver, usually in advance of patient handoff but always as part of the patient handoff.

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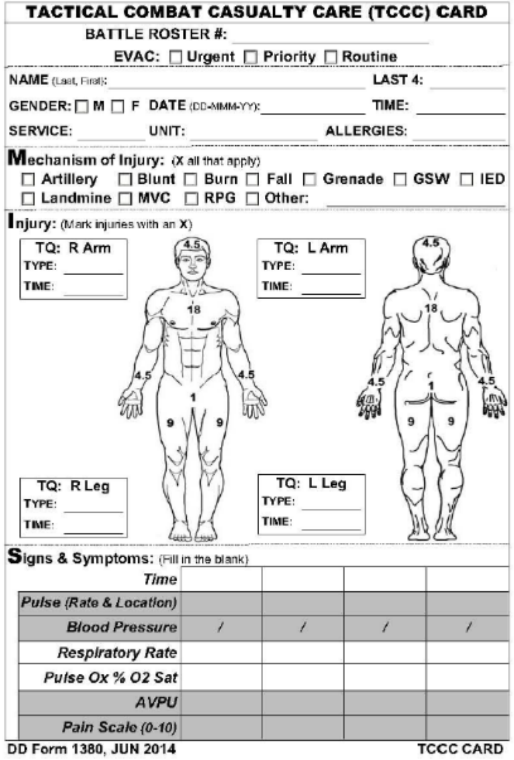
A combat medic completes the TCCC card at the Point Of Injury.

Info from the TCCC card is specified in the MMS FOM, so this data can be shared amongst interconnected systems.



TACTICAL COMBAT CASUALTY CARE (TCCC) CARD

BATTLE ROSTER #:

EVAC: ☐ Urgent ☐ Priority ☐ Routine

NAME (Last, First): LAST 4:

GENDER: ☐ M ☐ F DATE (DD-MMM-YY): TIME:

SERVICE: UNIT: ALLERGIES:

Mechanism of Injury: (X all that apply)

☐ Artillery ☐ Blunt ☐ Burn ☐ Fall ☐ Grenade ☐ GSW ☐ IED
☐ Landmine ☐ MVC ☐ RPG ☐ Other:

Injury: (Mark injuries with an X)

TQ: R Arm TYPE: TIME:

TQ: L Arm TYPE: TIME:

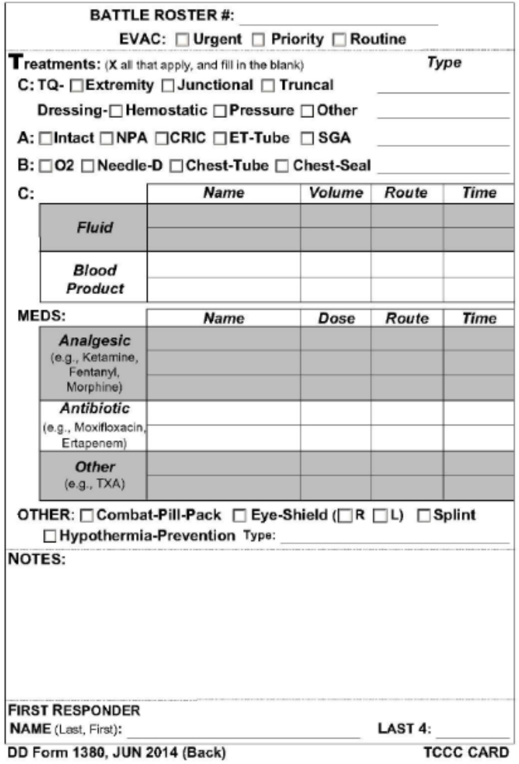
TQ: R Leg TYPE: TIME:

TQ: L Leg TYPE: TIME:

Signs & Symptoms: (Fill in the blank)

Time				
Pulse (Rate & Location)				
Blood Pressure	/	/	/	/
Respiratory Rate				
Pulse Ox % O2 Sat				
AVPU				
Pain Scale (0-10)				

DD Form 1380, JUN 2014 TCCC CARD



BATTLE ROSTER #:

EVAC: ☐ Urgent ☐ Priority ☐ Routine

Treatments: (X all that apply, and fill in the blank) Type

C: TQ- ☐ Extremity ☐ Junctional ☐ Truncal

Dressing- ☐ Hemostatic ☐ Pressure ☐ Other

A: ☐ Intact ☐ NPA ☐ CRIC ☐ ET-Tube ☐ SGA

B: ☐ O2 ☐ Needle-D ☐ Chest-Tube ☐ Chest-Seal

C:

	Name	Volume	Route	Time
Fluid				
Blood Product				

MEDS:

	Name	Dose	Route	Time
Analgesic (e.g., Ketamine, Fentanyl, Morphine)				
Antibiotic (e.g., Moxifloxacin, Ertapenem)				
Other (e.g., TXA)				

OTHER: ☐ Combat-Pill-Pack ☐ Eye-Shield (☐ R ☐ L) ☐ Splint
☐ Hypothermia-Prevention Type:

NOTES:

FIRST RESPONDER
NAME (Last, First): LAST 4:

DD Form 1380, JUN 2014 (Back) TCCC CARD

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Approach:

- Many years of experience in other simulation domains show that a Publish-Subscribe system architecture along with a standardized data object model would satisfy current and projected future needs for simulation-based medical training, whether standalone or distributed.
- The prime contractor for this contract chose “High Level Architecture” (HLA), an IEEE-controlled international simulation standard, as the data interchange architecture, because HLA fits this application very well.

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Benefits of HLA for Medical Simulation-based Training:

- Proven
  - IEEE standard … 20+ years of development and use … Suitable for small, large, and very large scale applications
- Efficient
  - Publish/Subscribe architecture
  - Quick (short time) to develop/adapt new applications
- Commercial off-the-shelf tools readily available from multiple suppliers
- Modular and Expandable
  - Future proof … No “stove-piped” (“dead-end”) implementations
- Time management
  - Real-time operation plus slower or faster than real-time operation
  - Time synchronized throughout the training systems
- Assured data delivery
  - Causality and Deterministic, needed for operational integrity & repeatability

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Wide Range of Medical Care Related Data:

Building a standardized Medical Modeling & Simulation Federation Object Model (MMS FOM) requires inclusion of many different categories of information. The MMS FOM defines the overall data infrastructure through which various medical-related simulators interchange data.

Any standalone or distributed medical training system may include these types of information <u>in full</u> or <u>in part</u>.

- Medical Facility
- Physiological
- Pharmacological
- Transfer of Patient
- Control of Simulation
- Logistics
- Communications
- Instructional

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MMS FOM Modules:

Several modules of the Medical Modeling & Simulation Federation Object Model (MMS FOM) are described in more detail in subsequent slides.

- **Medical Facility**
- **Physiological**
- Pharmacological
- Transfer of Patient
- Control of Simulation
- **Logistics**
- **Communications**
- Instructional

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Standardized Data … **Facilities**

Medical facility examples:

- The immediate area surrounding a combat medic treating a field casualty at the point of injury
  - In other words, the area around the point of injury is a medical "facility" where care is provided by a combat medic
- CASEVAC/MEDEVAC transportation vehicles
- Fixed facilities, such as field (tents) and regional hospitals
- Mobile hospitals, e.g. US Navy "Mercy" ship

Facility info includes the number of beds, providers, other info

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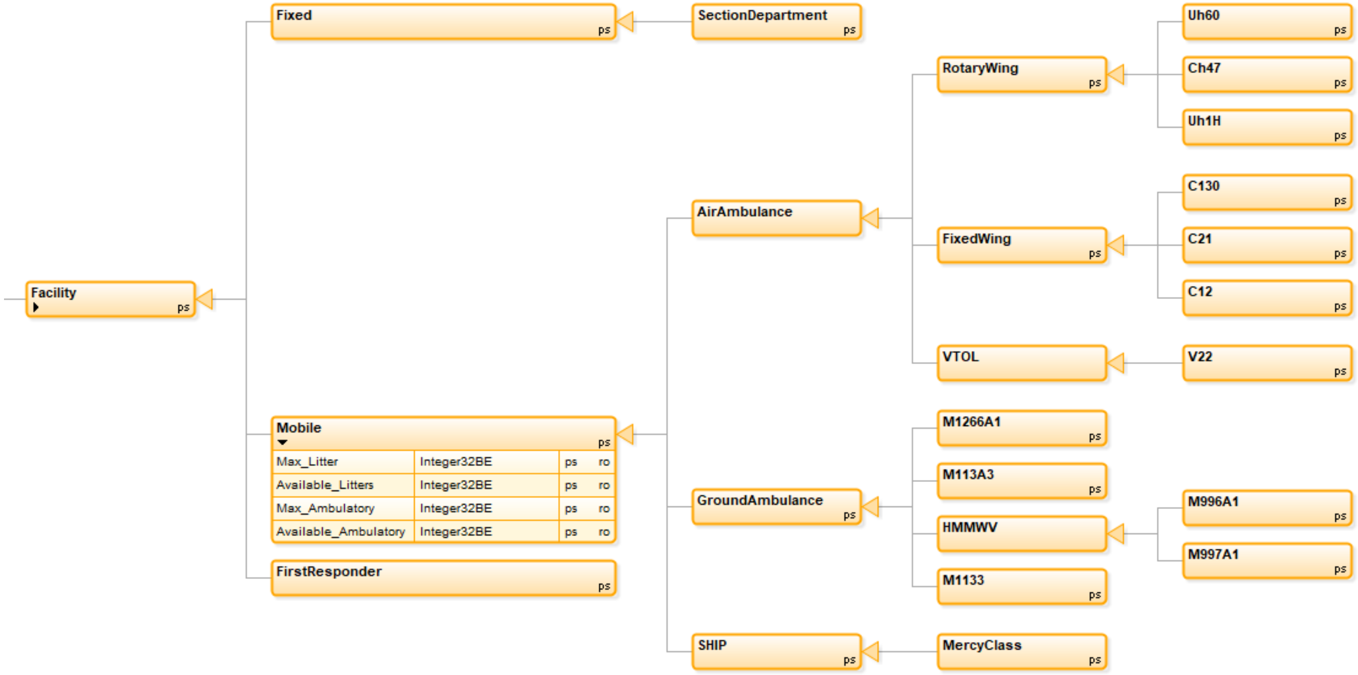
Standardized Data … **Facilities**



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Standardized Data … **Physiological**

The Physiological module contains data definitions involving:

- Patients
  - Identification, vital signs, oxygen level in blood, others
- Injuries
  - Injury types (standard medical codes)
- Treatments
  - Medicines given, topical treatments, tourniquets, etc

PatientPhysiology (ps)

patientID	HLAASCIIstring	ps	ro
heartRate	Integer32BE	ps	ro
heartDiastolicBloodPressure	FloatType32BE	ps	ro
heartSystolicBloodPressure	FloatType32BE	ps	ro
peripheralOxygenSaturation	FloatType32BE	ps	ro
temperatureFahrenheit	FloatType32BE	ps	ro
respirationETco2	FloatType32BE	ps	ro
respirationRate	FloatType32BE	ps	ro
lungTidalVolume	Integer32BE	ps	ro
lungDeadSpace	Integer32BE	ps	ro
lungTotalCapacity	Integer32BE	ps	ro
lungExpiratoryReserve	Integer32BE	ps	ro
lungInspiratoryReserve	Integer32BE	ps	ro
lungResidualVolume	Integer32BE	ps	ro

Injury (ps)

patientID	HLAASCIIstring	ps	ro
injuryID	HLAASCIIstring	ps	ro
injuryType	InjuryTypeEnum	ps	ro
injuryLocation	BodyLocationEnum	ps	ro
injuryTime	HLAinteger64Time	ps	ro

Treatment (ps)

PatientDemographics (ps)

PatientEvaluation (ps)

PatientPathology (ps)

PatientLocation (ps)

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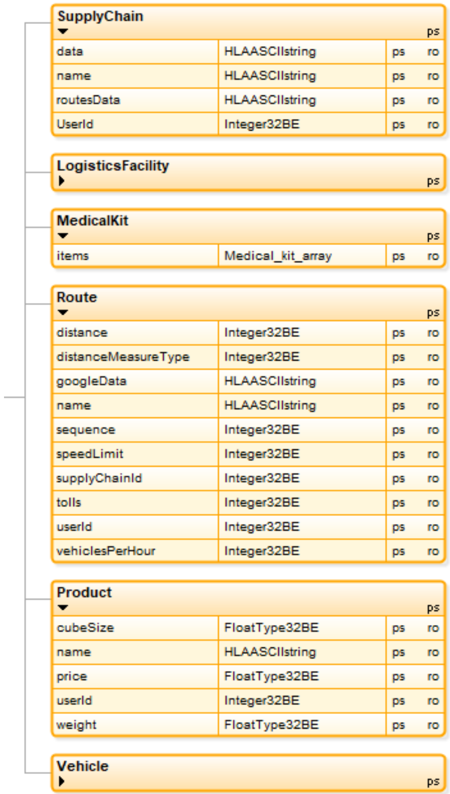
Standardized Data … **Logistics**

The Logistics module contains data definitions for tracking of medical supplies and related materials, plus transportation, including routing, of supply vehicles.

- Products
  - Product Names & Part Numbers
  - Packaging (weights and sizes)
- Info about Routes
  - Route planning and deployment
- Info about logistics facilities
  - Locations
  - Stocks (inventories)
- Supply Vehicles



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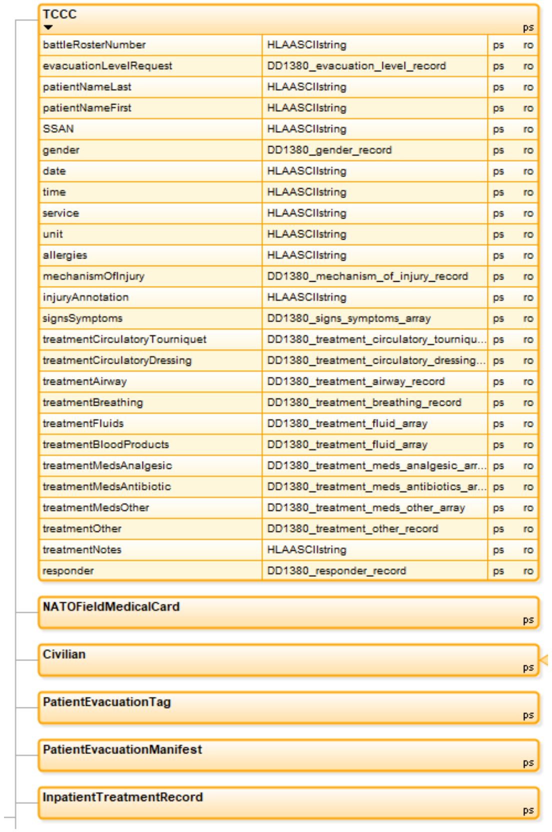
Standardized Data … **Comms**

The MMS FOM's Comms module defines data types used in verbal and written communications between medical care personnel

- Example use: radio transmission of military medical documents including the TCCC card used by combat medics at the Point Of Injury.



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Results:

A demo Point of Injury related training system of systems is being constructed to verify the approach and first implementation of the Medical Modeling & Simulation Federation Object Model (MMS FOM). Key components are:

- Interactive 3D visualization ("serious game")
- Highly advanced physiology engine
- Simulated CASEVAC/MEDEVAC operations
- Capture of patient and treatment data
- Capture of voice communications and related written documentation, in the forms mandated by US DOD policies
- Tracking medical supplies via automated interaction with a Logistics system
- Integration with a formal Learning Management System (LMS)

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Lessons Learned:

1. Most medical training devices today were not designed to be interoperable.
    - Commercial off-the-shelf HLA tools provided a straightforward path to add HLA compatibility to devices and training systems used in our demo.
2. The standardized MMS FOM provides a well-documented data interchange model.
    - It took time “up front” to determine the data Input and Output capabilities and requirements of each component system, but having a standardized MMS FOM enables previously disconnected systems to interoperate with minimal stress on systems or personnel.

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Lessons Learned:

3. Implementing interoperability using a modern, robust simulation framework (HLA) with a standardized data model and modern software tools was relatively easy to do and produced excellent results.
4. Building a modern interoperable system on the basis of old standard forms (paper documents) that have been in field use for years, sometimes decades, was definitely challenging. HLA’s modularity and flexible data types enabled our adaptation of paper forms to electronic data.
5. It was critically important to have Subject Matter Experts (SMEs) available to consult (e.g. medical SMEs, logistics SMEs, etc)

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Conclusions:

1. HLA proved to be a viable architecture for simulation-based training of medical personnel.
2. HLA enabled interoperability of previously standalone systems and training products.
3. Making a standardized object model, the MMS FOM, took time to coordinate but was worth the effort.
4. Future training systems can benefit from our work, building on the current baseline and adding modules when needed.

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Biographies:

DAMON CURRY (presenter and co-author): Pitch Technologies’ manager for business development in North America, Damon has 30+ years in the simulation industry specializing in distributed training systems, 3D visualization, and 3D terrain. He presently has 2 patents pending related to wireless video for virtual reality. BS Electrical Engineering, The Ohio State University.

BJORN LÖFSTRAND (co-author): Services and Training Manager at Pitch Technologies, and senior systems architect in modelling and distributed simulation design. Mr. Löfstrand has been engaged in national, international (SISO) and NATO M&S standardization activities since mid-90's. Mr. Löfstrand has a M.Sc. in Computer Science from the University of Linköping (Sweden).

DANNIE CUTTS (co-author): Senior Computer Scientist supporting Pitch Technologies. He has been involved with the High Level Architecture since 1995, supporting HLA federation development for NASA and the US DoD. He is a Certified Modeling & Simulation Professional and serves on the IEEE Drafting Group for the HLA 1516 standard.

ERIN HONOLD (co-author): Biomedical Engineer with IVIR Inc. with experience developing medical simulation technologies and architectures for the US Department of Defense. Previous work includes utilizing HLA to design standard architectures for joint medical training focusing on en route care and patient handoffs.

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