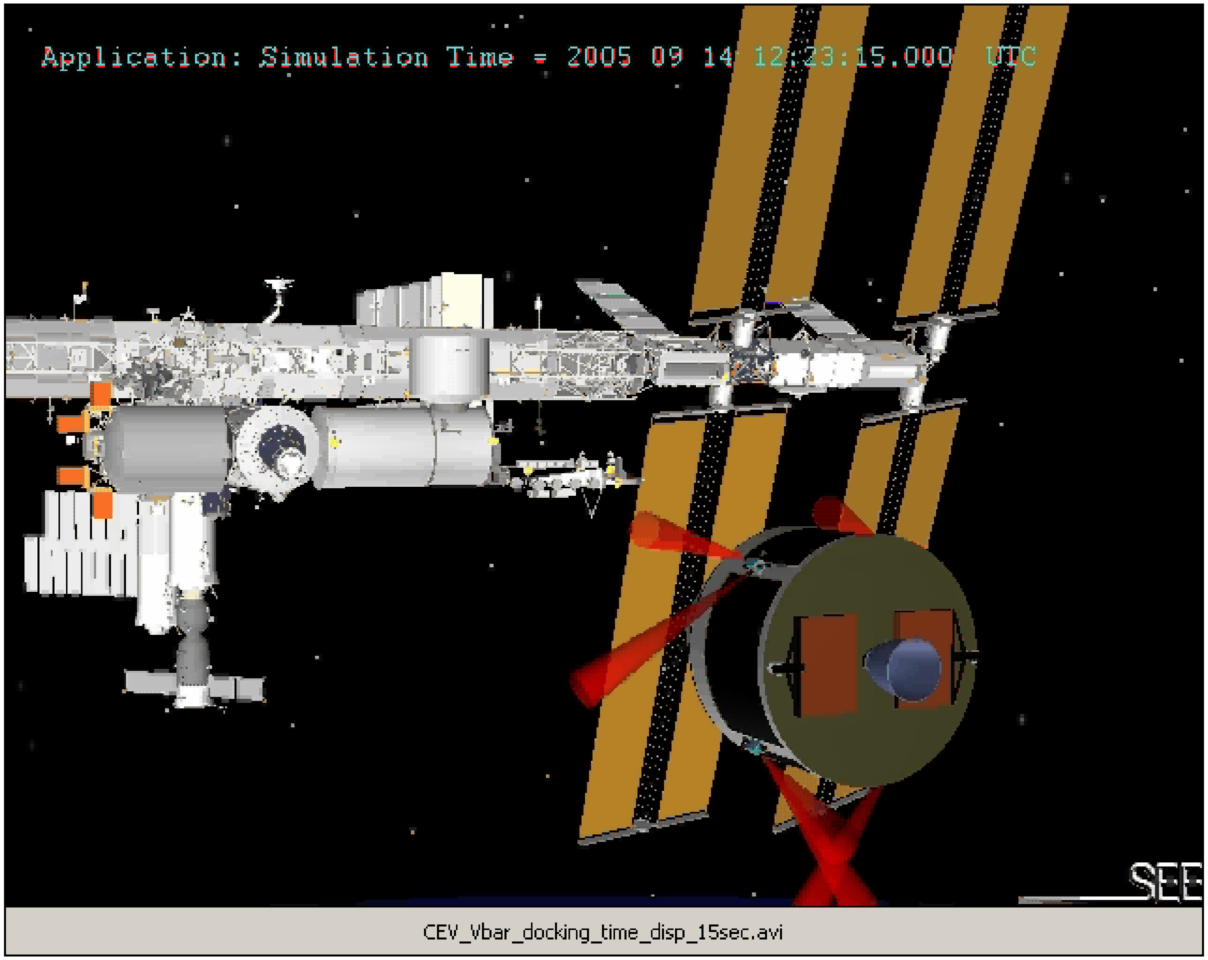
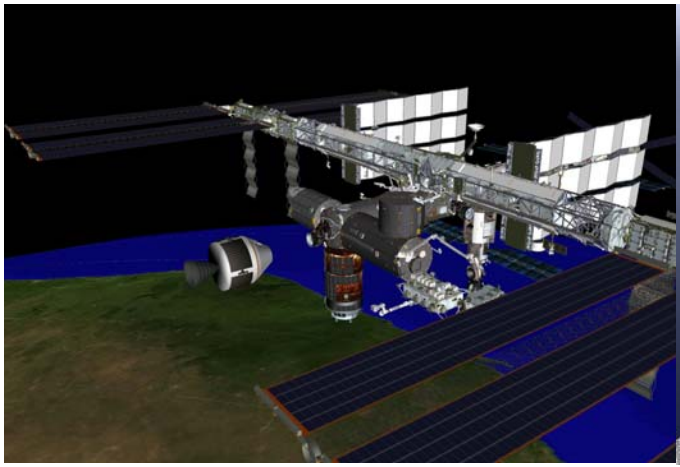
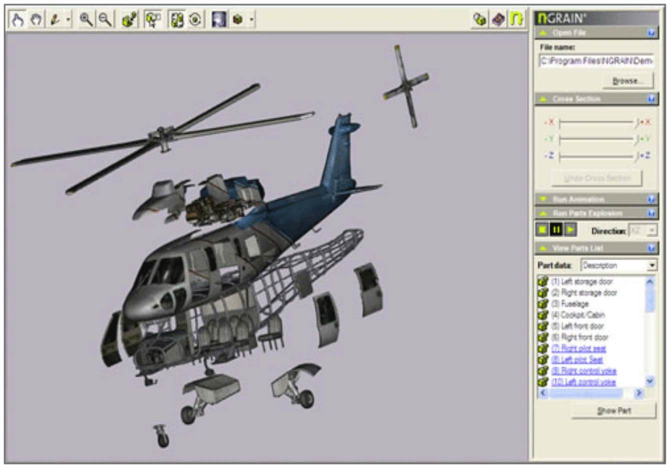


Application: Simulation Time = 2005 09 14 12:23:15.000 UTC

CEV_Vbar_docking_time_disp_15sec.avi





File name: C:\Program Files\NGRAIN\Dem

Direction: XZ

Part data: Description

(1) Left storage door
(2) Right storage door
(3) Fuselage
(4) Cockpit/Cabin
(5) Left front door
(6) Right front door
(7) Right pilot seat
(8) Left pilot Seat
(9) Right control yoke
(10) Left control yoke

SYSTEM SAFETY REQUIREMENTS:

Verification, Validation and Accreditation (VV&A) for Modeling and Simulation

Major A.J. Masys

DND Synthetic Environment Coordination Office

19 April 07

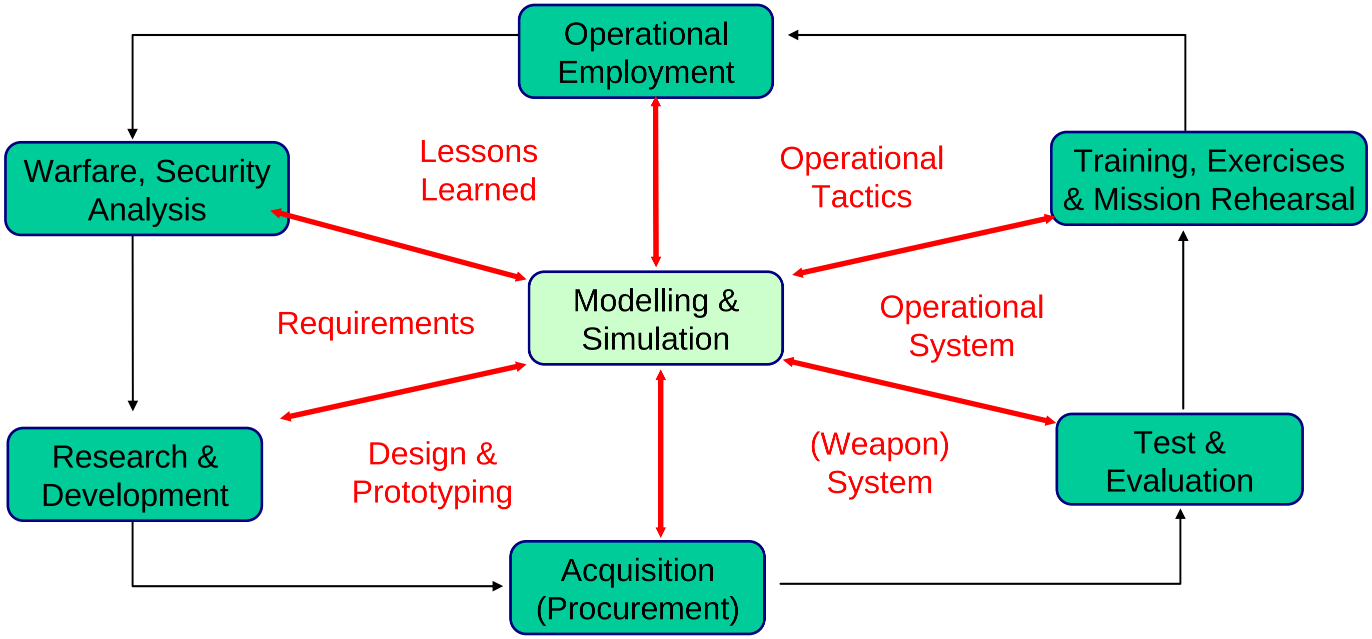
Outline

- Modelling and Simulation
- System Safety, M&S applications
- VV&A
- Recent initiatives
  - IEEE 1516.4 VV&A Overlay to FEDEP
  - REVVA 2
  - SISO GM V&V
- Conclusion

Modelling and Simulation (M&S)

- M&S is an enabling technology that is used across many domains including the physical sciences, engineering and social sciences
- M&S facilitates decision-making
  - Provides insights into a problem space
  - Contributions to system safety design and operation

Domain of M&S


Operational Employment
Warfare, Security Analysis
Training, Exercises & Mission Rehearsal
Lessons Learned
Operational Tactics
Modelling & Simulation
Requirements
Operational System
Research & Development
Design & Prototyping
(Weapon) System
Test & Evaluation
Acquisition (Procurement)

IMPLEMENTATION PHASE

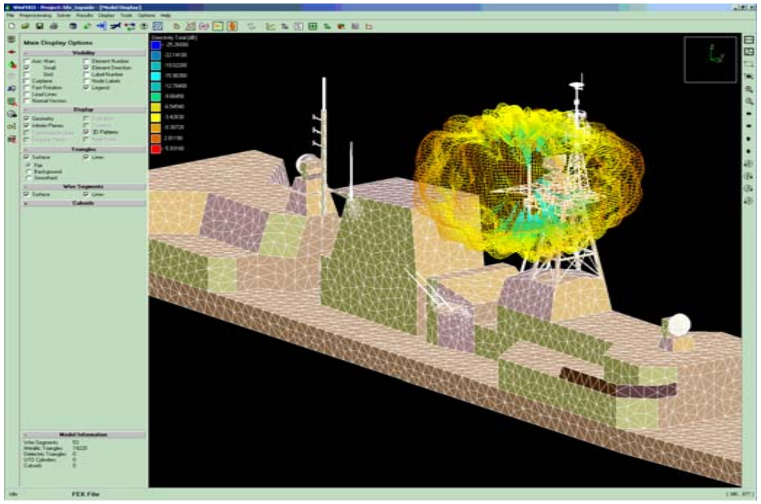
Shipboard Electro-Optical Surveillance System (SEOSS) Project (QETE, DGMEPM)

Cost $50,000

Prevented performance problems

Resulted in $500,000 cost avoidance

Cut one year from the schedule



M and S and Procurement Reform in Support of Operations: Landmine Identification and Disassembly

The Requirement: Prepare / train Canadian soldiers to identify and disassemble 70 different types of mines in Afghanistan.

Traditional approach

- Buy as many training versions of the most common mines as you can afford.
- Procurement lead time from 6 to 18 months (Urgent operational requirement) to 5 to 15 years (normal capital project).
- Ration allocation by unit.
- Estimated cost $5 million, plus salaries and travel

M&S Reformed Approach

- Develop virtual mines
- Model each type in five days or less.
- Each model permits identification, making safe, and disassembly training.
- Replicate entire data base on CD unlimited times.
- Train anywhere, use anywhere on laptop, PDA.
- Share with armies around the world (Egypt, Uganda, Kenya, South Africa)

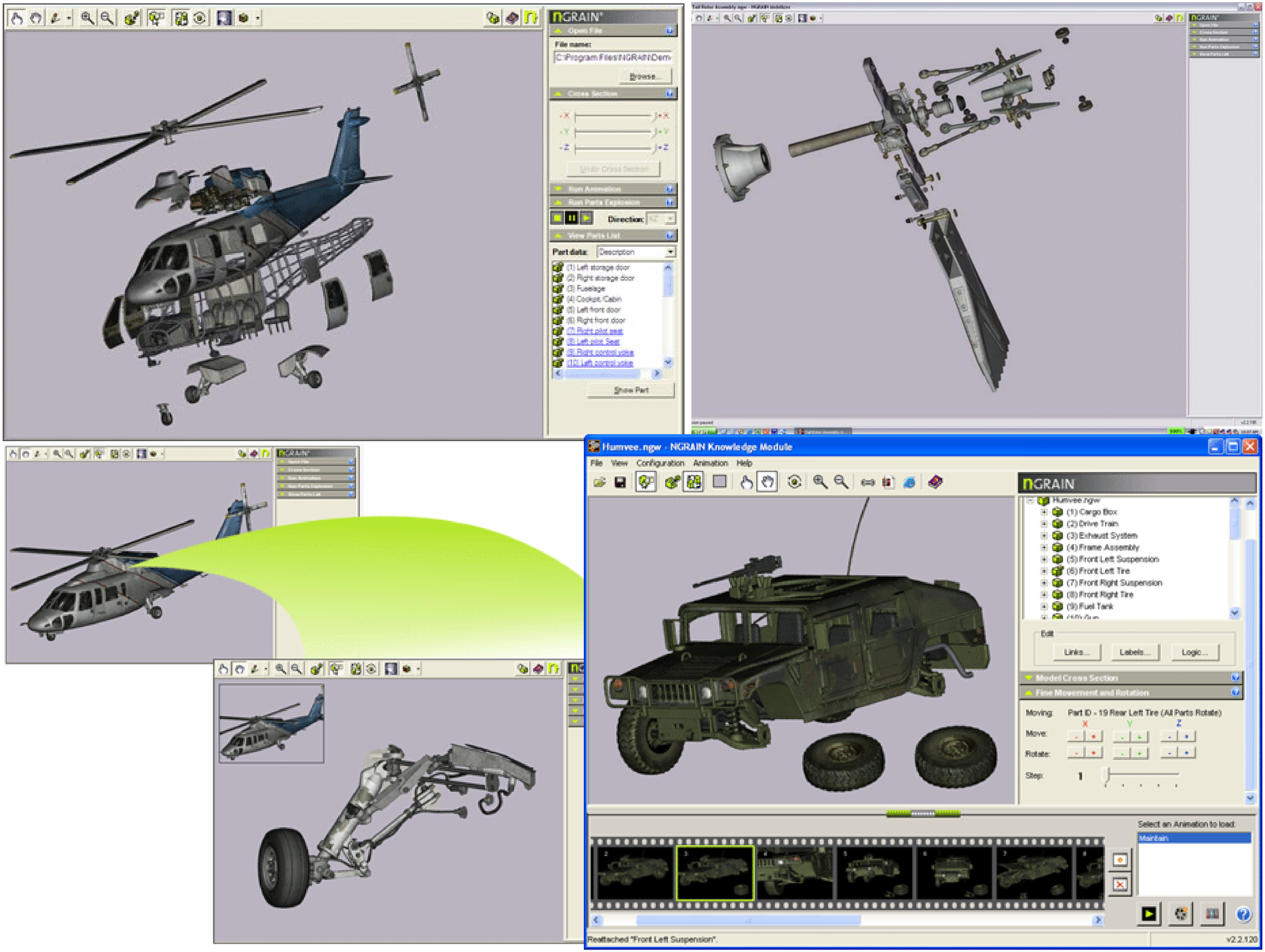
M&S In Support of Operations

The M&S landmine solution:

- **Produced capability in days, not years**
- **Cost $200,000 vs $5,000,000**
- **Did not limit capability to selected units, locations**
- **Capability went into the field in Afghanistan on laptop**
- **Unlimited replication at minimal cost**

Description: Spotting Charge

"The speed at which interactive 3D content can be produced, distributed and viewed means that personnel have the tools necessary to execute the mission where and when needed. The …. Solution makes the knowledge and expertise in our organization accessible anywhere, anytime, resulting in reduced safety risks through better training and instant access to critical information in the field." Master Warrant Officer Tom Stewart, Canadian Forces, J3 Engineer Operations.



Humvee.ngw - NGRAIN Knowledge Module

File name: C:\Program Files\NGRAIN\Dem

Part data: Description

(1) Left storage door
(2) Right storage door
(3) Fuselage
(4) Cockpit/Cabin
(5) Left front door
(6) Right front door
(7) Right pilot seat
(8) Left pilot Seat
(9) Right control yoke
(10) Left control yoke

Humvee.ngw
(1) Cargo Box
(2) Drive Train
(3) Exhaust System
(4) Frame Assembly
(5) Front Left Suspension
(6) Front Left Tire
(7) Front Right Suspension
(8) Front Right Tire
(9) Fuel Tank

Moving: Part ID - 19 Rear Left Tire (All Parts Rotate)

Step: 1

Select an Animation to load: Maintain

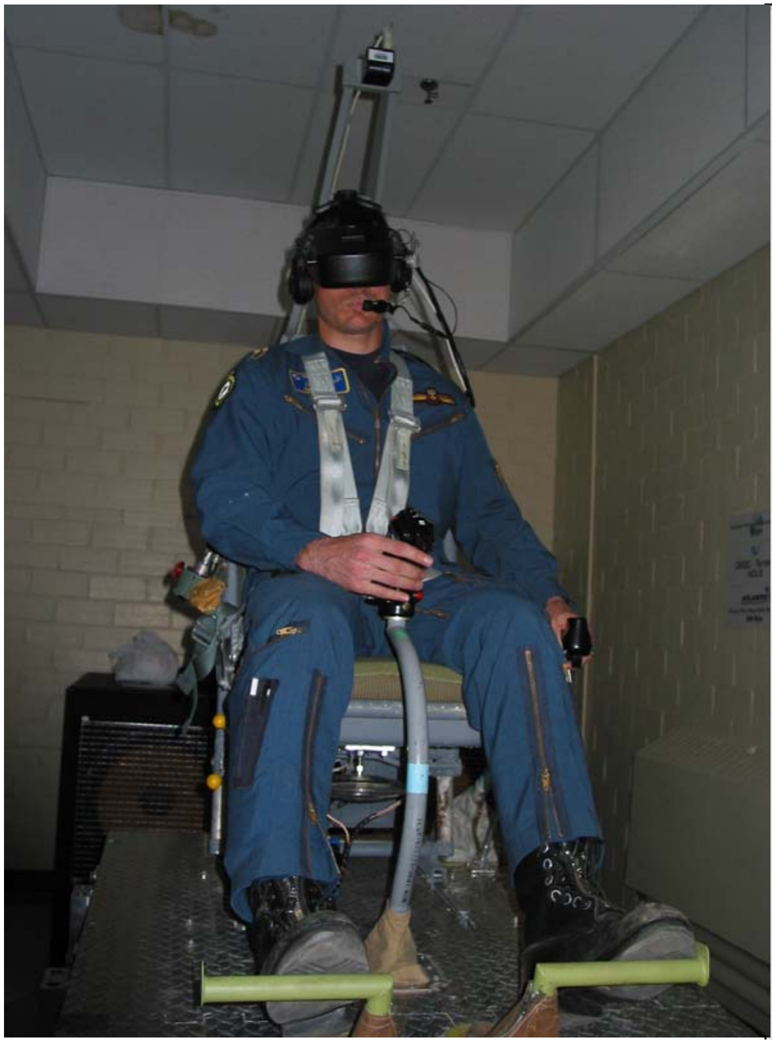
Reattached "Front Left Suspension".

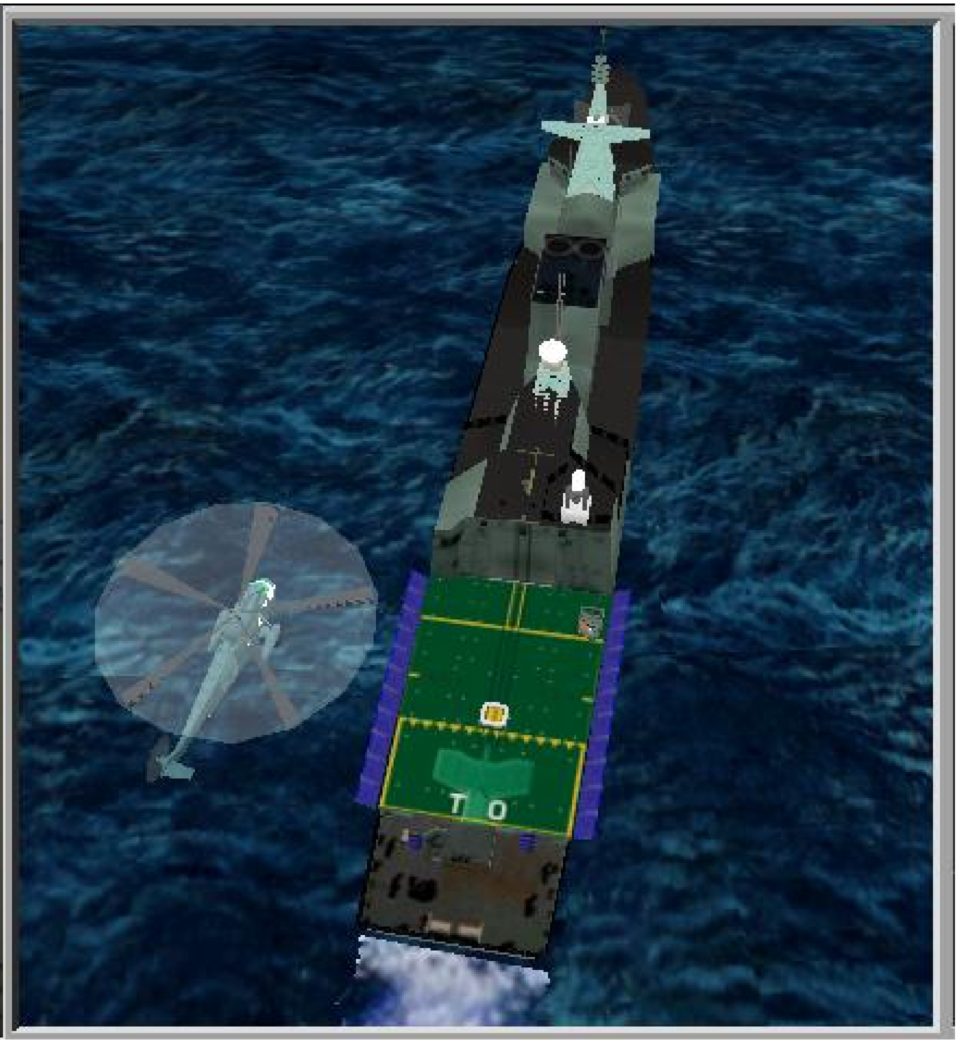
HelMet Vision

- The Sea King Helicopter Maritime Environment Trainer (HelMET) is designed to provide comprehensive initial and refresher training in a virtual environment for pilots of Sea King helicopters in landing on a flight deck of a Canadian Patrol Frigate (CPF).

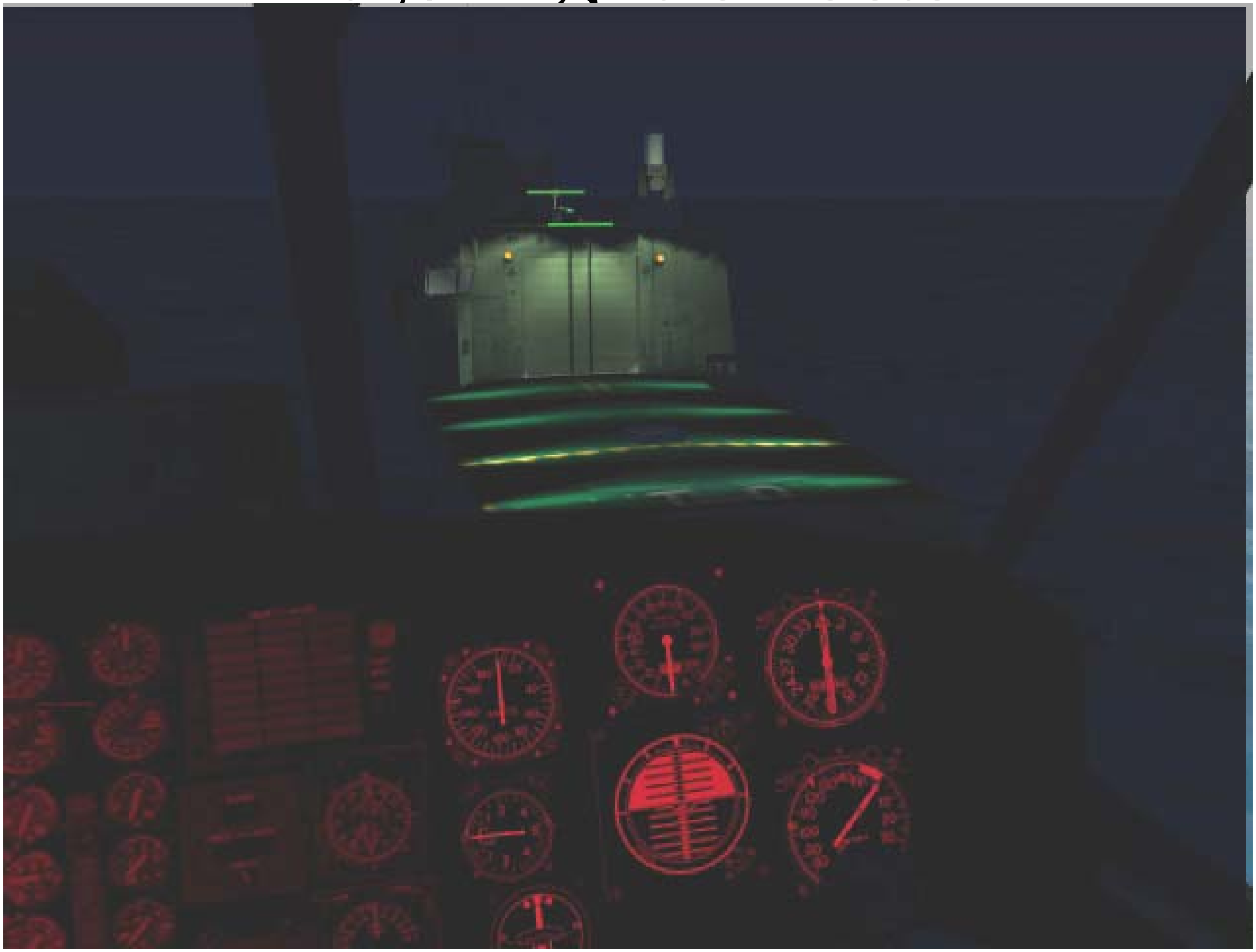
- Use of the simulator provides for effective training and evaluation while minimizing the high cost of operating ship and aircraft for training missions and eliminating the inherent danger of personal injury and/or damage of aircraft and/or ship."

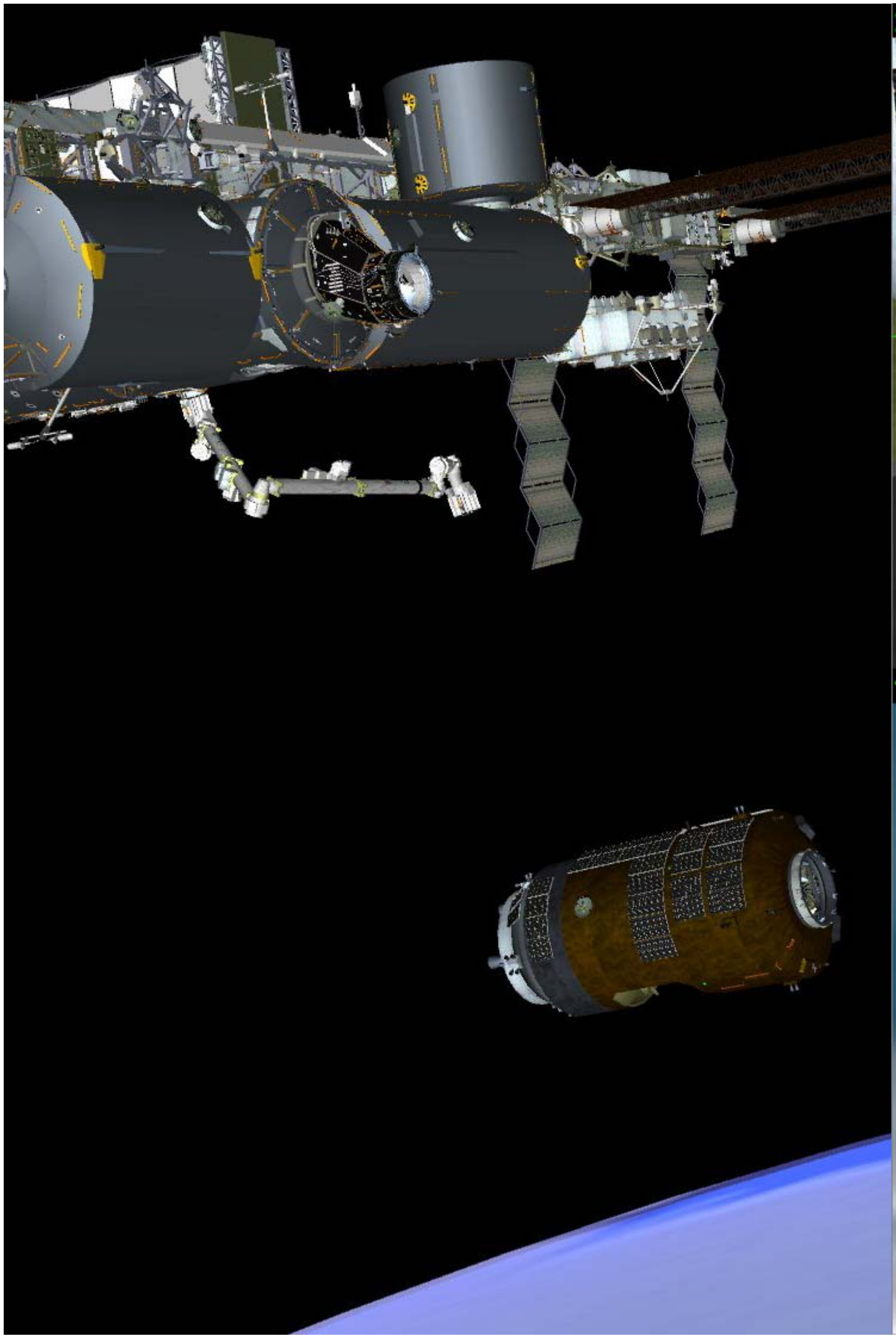
Helicopter Maritime Environment Trainer (HelMET)

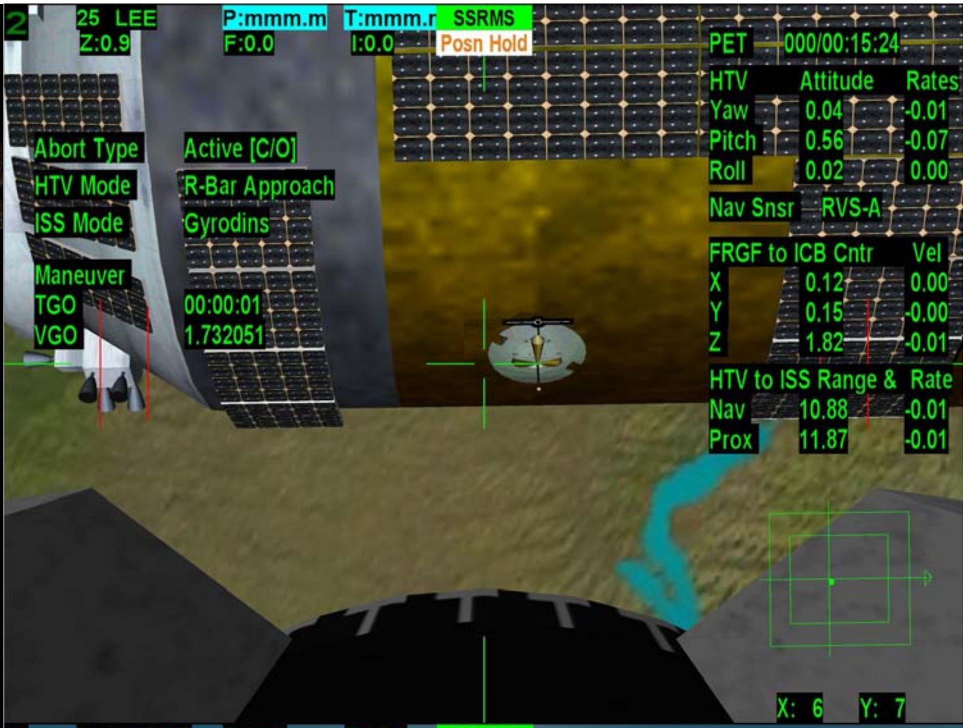




Day/Night effects







2

25 LEE
Z:0.9

P:mmm.m
F:0.0

T:mmm.r
I:0.0

SSRMS
Posn Hold

Abort Type Active [C/O]
HTV Mode R-Bar Approach
ISS Mode Gyrodins

Maneuver
TGO 00:00:01
VGO 1.732051

PET 000/00:15:24

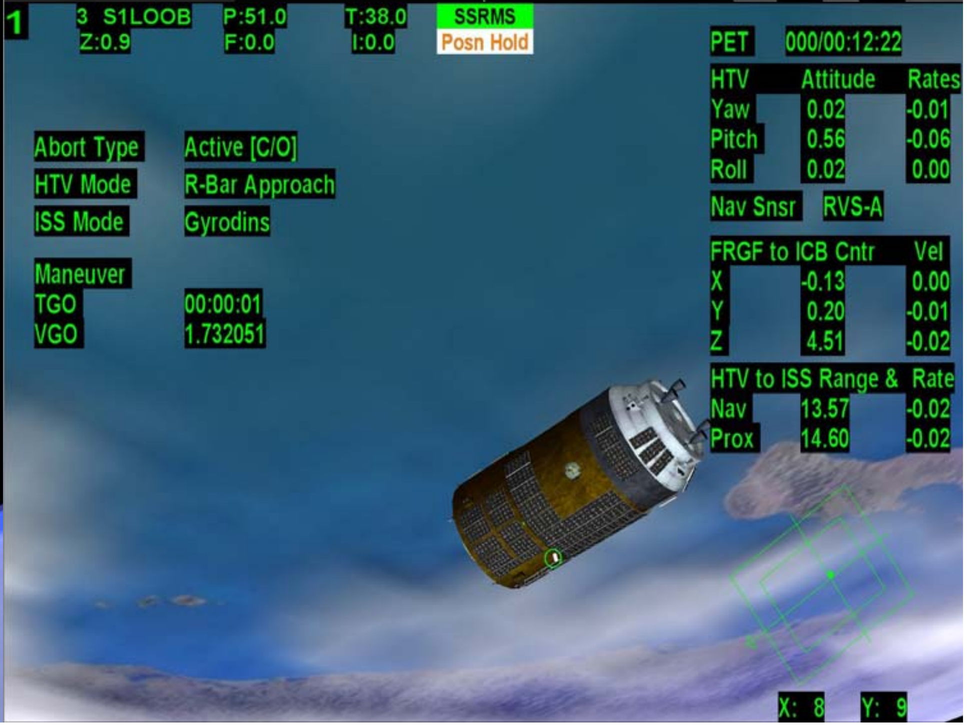
HTV	Attitude	Rates
Yaw	0.04	-0.01
Pitch	0.56	-0.07
Roll	0.02	0.00

Nav Snsr RVS-A

FRGF to ICB Cntr		Vel
X	0.12	0.00
Y	0.15	-0.00
Z	1.82	-0.01

HTV to ISS Range &		Rate
Nav	10.88	-0.01
Prox	11.87	-0.01

X: 6 Y: 7



1

3 S1LOOB
Z:0.9

P:51.0
F:0.0

T:38.0
I:0.0

SSRMS
Posn Hold

Abort Type Active [C/O]
HTV Mode R-Bar Approach
ISS Mode Gyrodins

Maneuver
TGO 00:00:01
VGO 1.732051

PET 000/00:12:22

HTV	Attitude	Rates
Yaw	0.02	-0.01
Pitch	0.56	-0.06
Roll	0.02	0.00

Nav Snsr RVS-A

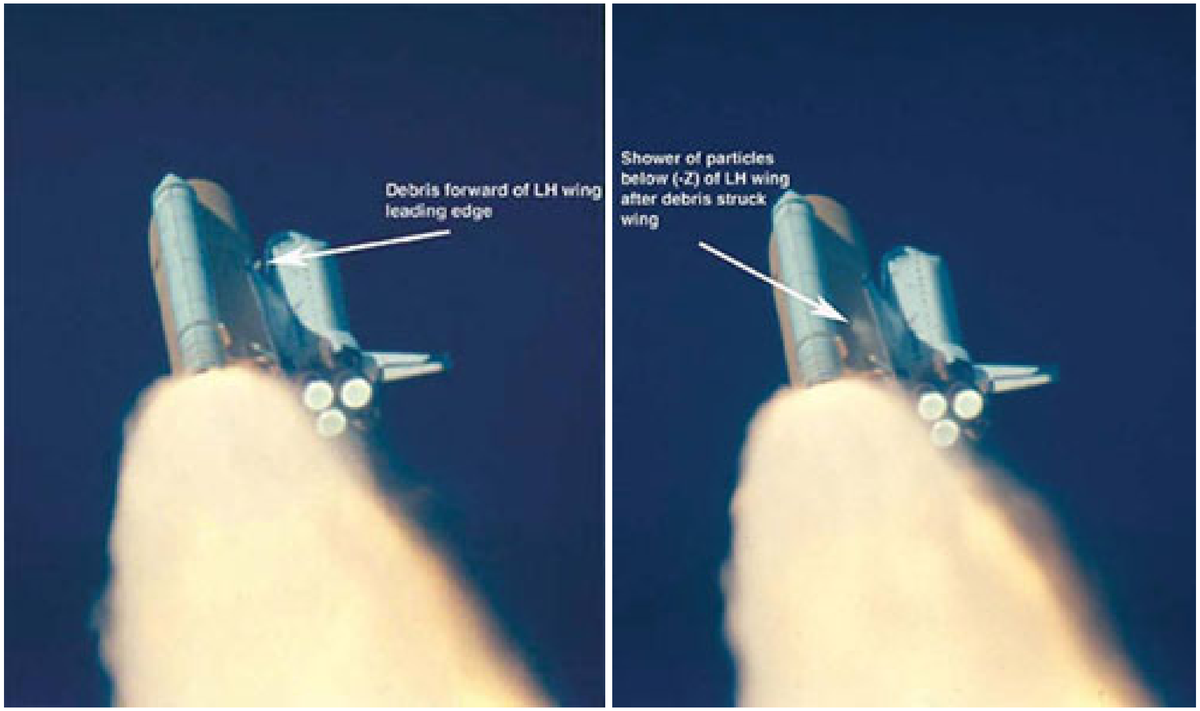
FRGF to ICB Cntr		Vel
X	-0.13	0.00
Y	0.20	-0.01
Z	4.51	-0.02

HTV to ISS Range &		Rate
Nav	13.57	-0.02
Prox	14.60	-0.02

X: 8 Y: 9

NASA Interim M&S Standard

- The primary goal of this standard is to ensure that the credibility of the results from models and simulations (M&S) is properly conveyed to those making critical decisions.
- This will support risk-informed decisions. (By “critical decisions” we mean decisions that may affect human safety or project defined mission success criteria.)


Debris forward of LH wing leading edge
Shower of particles below (-Z) of LH wing after debris struck wing

- *Engineering analysis (involving the Crater simulation) conducted during the flight concluded for NASA managers that although the foam might have caused some structural damage to the wing area, it would not have been sufficient to cause a catastrophic event." R. Dittemore, Columbia mission manager, February 3, 2003.*

- *"The use of Crater in this new and very different situation compromised NASA's ability to accurately predict debris damage in ways that Debris Assessment Team engineers did not full comprehend." CAIB Report, August 2003*

Slide Content Courtesy of Scott Harmon.

- *“Efforts to validate the DarkStar at the system level fell short as well. The modeling and simulation that was conducted before flight testing was not high quality and did not have sufficient fidelity. It was cited as one of the factors that caused the crash.” (GAO/NSIAD-00-199)*

- *In February 1999, DarkStar program was canceled.” (GAO/NSIAD-00-199)*

Verification, Validation & Accreditation (VV&A)

- Modelling and Simulation is increasingly being used to facilitate problem solving and decision making within the system safety domain.
- "The developers and users of these models, the **decision makers** using information derived from the results of these models, and people affected by decisions based on such models are all rightly concerned with whether a model and its **results are correct**. This concern is addressed through model verification and validation." [1]

[1] Sargent, R.G. Some Approaches and Paradigms for Verifying and Validating Simulation Models. Published in the Proceedings of the 2001 Winter Simulation Conference. Pg 106.

VV&A

- “Verification, Validation, and Accreditation (VV&A) are three interrelated but distinct processes that gather and evaluate evidence to determine the simulation’s capabilities, limitations, and performance relative to the real-world object that it simulates, based on the simulation’s intended use.
- The goal of VV&A is to assist the user in making an informed and independent judgment in regards to the credibility of Models and Simulations (M&S) being used in a specific program or project of interest to the user.” [2]

[2]. Tullos-Banks, H.L., Parker, C.T., Collins, K.W. Verification, Validation and Accreditation of Federations. Published in the Proceedings of the Spring Simulation Interoperability Workshop (SIW): 05S-SIW-022, San Diego, Ca. Apr 2005.

Definitions

- Verification
  - defined as the process of determining that a model implementation and its associated data accurately represent the developer's conceptual description and specifications.
  - Verification evaluates the extent to which the model or simulation has been developed using sound and established software and system engineering techniques (IEEE, 1997).

Definitions

- Validation
  - defined as the process of determining the degree to which a distributed simulation is an accurate representation of the real world from the perspective of the intended use(s) as defined by the requirements.
  - Validation also refers to the process of determining the confidence that should be placed on this assessment (IEEE, 1997).

Definitions

- Accreditation
  - is the official certification that a model, simulation, or federation of models and simulations and its associated data are acceptable for use for a specific purpose.
- Acceptance
  - The decision to use a simulation for a specific purpose- ‘accepted for use’

International V&V Initiatives

NATO Modeling and Simulation Group	NMSG-019 / TG-016 VV&A of Federations
SISO Simulation Interoperability Standards Organization www.sisostds.org	SISO PDG V&V of Federations
REVVA 1 and REVVA 2 Project	REVVA 2 V&V of M&S
SISO Simulation Interoperability Standards Organization www.sisostds.org	GM V&V SG Generic V&V Process

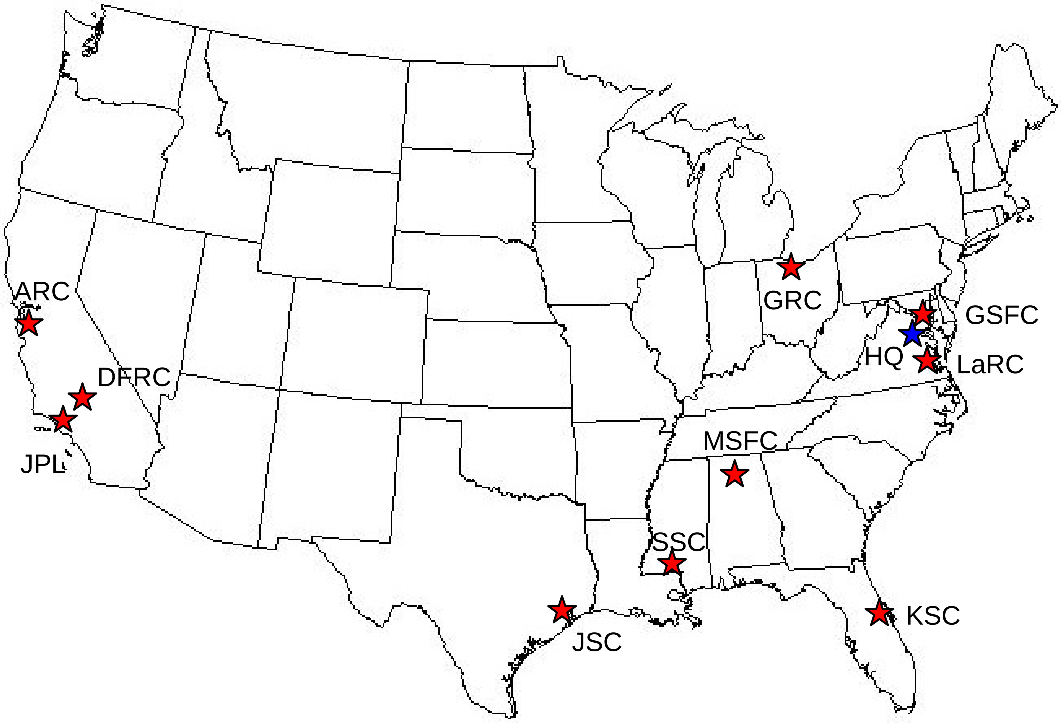
NMSG 19/ TG 016
Verification, Validation, and Accreditation (VV&A) of Federations

Distributed Simulation

- Distributed simulations provide an architecture that facilitates opportunities to interconnect multiple simulations in support of joint training objectives

Simulation Interoperability at NASA

- Distributed Research Locations
  - 10 NASA Centers
  - International Partners
- Distributed Human Resources
  - Science and engineering domain expertise
  - Software engineering and programming expertise
  - Computer and network engineering expertise
- Distributed Computer Resources
  - Thousands of Computers
  - Dedicated High Speed Computer Networks
- Distributable Problems
  - Systems with well defined interfaces
  - Simulation domains with separable dynamics



ARC - Ames Research Center

DFRC - Dryden Flight Research Center

GRC - Glenn Research Center

GSFC - Goddard Space Flight Center

JPL - Jet Propulsion Laboratory

JSC - Johnson Space Center

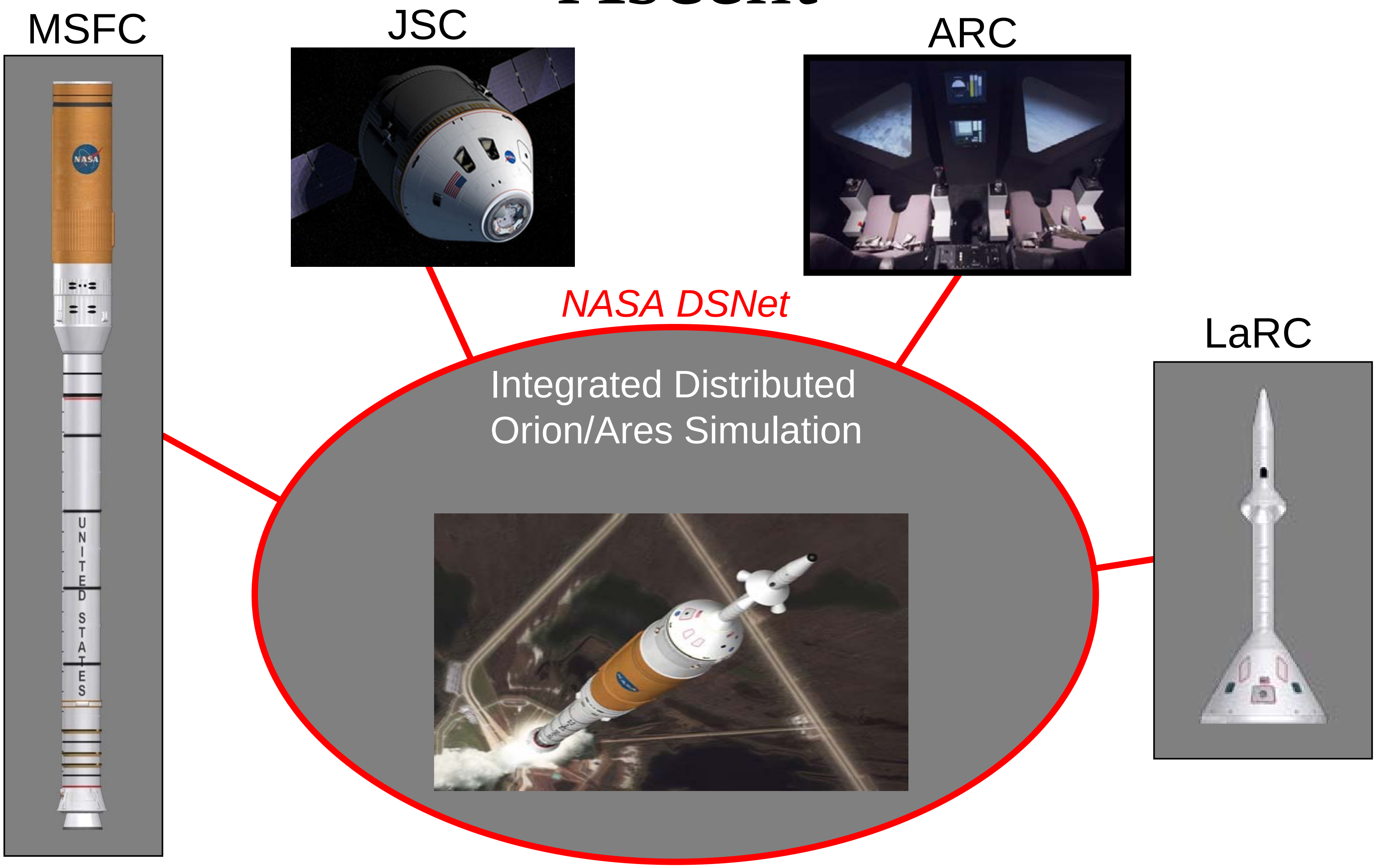
KSC - Kennedy Space Center

LaRC - Langley Research Center

MSFC - Marshall Space Flight Center

SSC - Stennis Space Center

DSES Orion/Ares Launch and Ascent



MSFC

JSC

ARC

LaRC

NASA DSNet

Integrated Distributed Orion/Ares Simulation

High Level Architecture (HLA)

- The High Level Architecture (HLA) has been designed to facilitate interoperability among simulations and to promote reuse of simulations and their components.
- In an HLA application, any number of physically distributed simulation systems can be brought together into a unified simulation environment to address the needs of new applications.

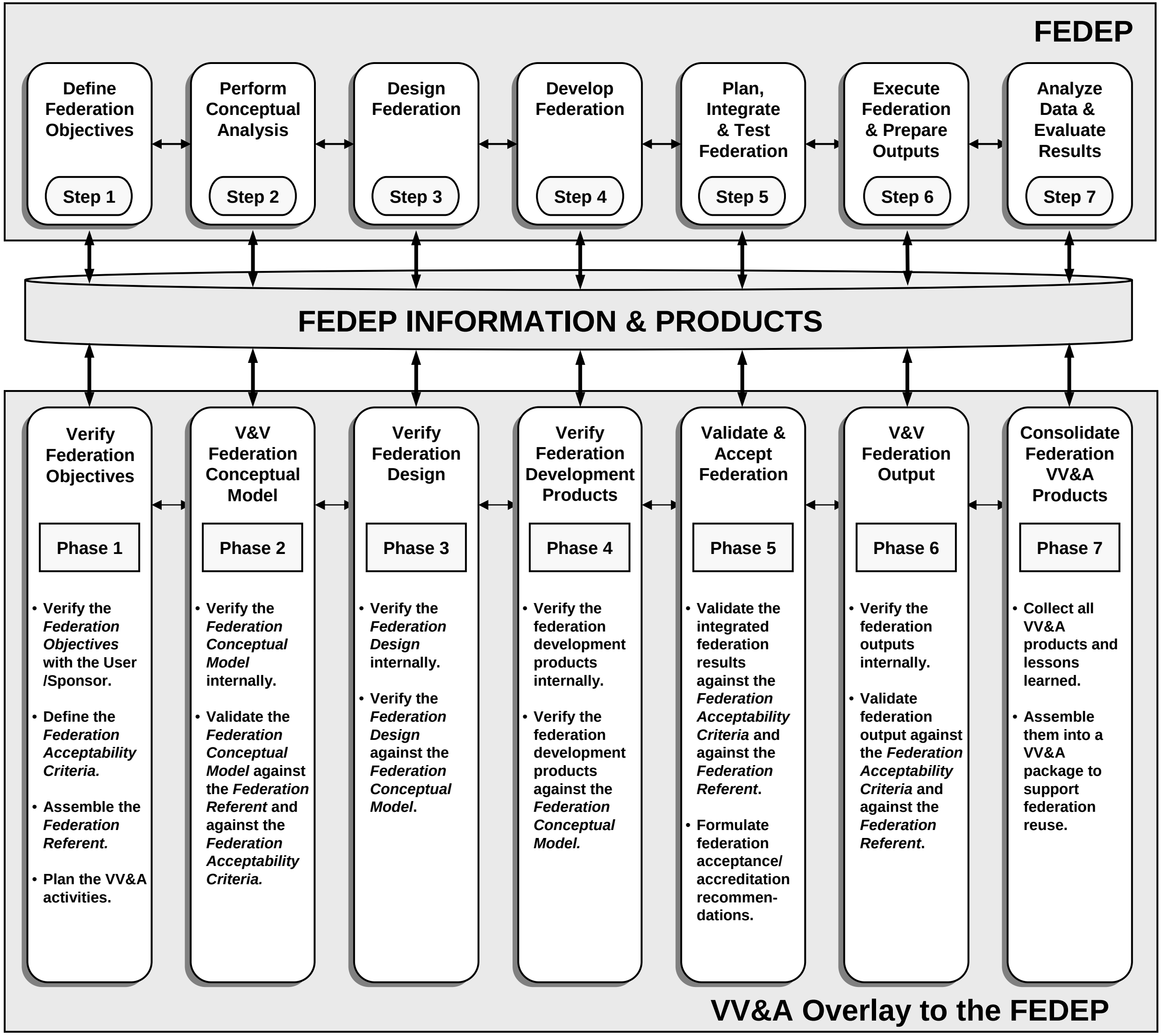
Federation Development and Execution Process (FEDEP)

- The FEDEP Model describes a high-level framework for the development and execution of HLA federations.
- The intent of the FEDEP Model is to specify a set of guidelines for federation development and execution that federation stakeholders can leverage to achieve the needs of their application.

VV&A Overlay

- The purpose of the VV&A overlay is to provide a more detailed view of the VV&A processes implied by the FEDEP.
  - Currently, these processes represent the best practices available to the VV&A community.
- The VV&A overlay is a tailorable process and is offered as guidance to all participants in FEDEP activities. The VV&A overlay identifies and describes the recommended VV&A processes that should be followed to assure the acceptability and utility of federations for particular intended uses.

VV&A Overlay



FEDEP

Define Federation Objectives — Step 1

Perform Conceptual Analysis — Step 2

Design Federation — Step 3

Develop Federation — Step 4

Plan, Integrate & Test Federation — Step 5

Execute Federation & Prepare Outputs — Step 6

Analyze Data & Evaluate Results — Step 7

FEDEP INFORMATION & PRODUCTS

Verify Federation Objectives

Phase 1

- Verify the *Federation Objectives* with the User /Sponsor.
- Define the *Federation Acceptability Criteria.*
- Assemble the *Federation Referent.*
- Plan the VV&A activities.

V&V Federation Conceptual Model

Phase 2

- Verify the *Federation Conceptual Model* internally.
- Validate the *Federation Conceptual Model* against the *Federation Referent* and against the *Federation Acceptability Criteria.*

Verify Federation Design

Phase 3

- Verify the *Federation Design* internally.
- Verify the *Federation Design* against the *Federation Conceptual Model*.

Verify Federation Development Products

Phase 4

- Verify the federation development products internally.
- Verify the federation development products against the *Federation Conceptual Model.*

Validate & Accept Federation

Phase 5

- Validate the integrated federation results against the *Federation Acceptability Criteria* and against the *Federation Referent*.
- Formulate federation acceptance/ accreditation recommendations.

V&V Federation Output

Phase 6

- Verify the federation outputs internally.
- Validate federation output against the *Federation Acceptability Criteria* and against the *Federation Referent*.

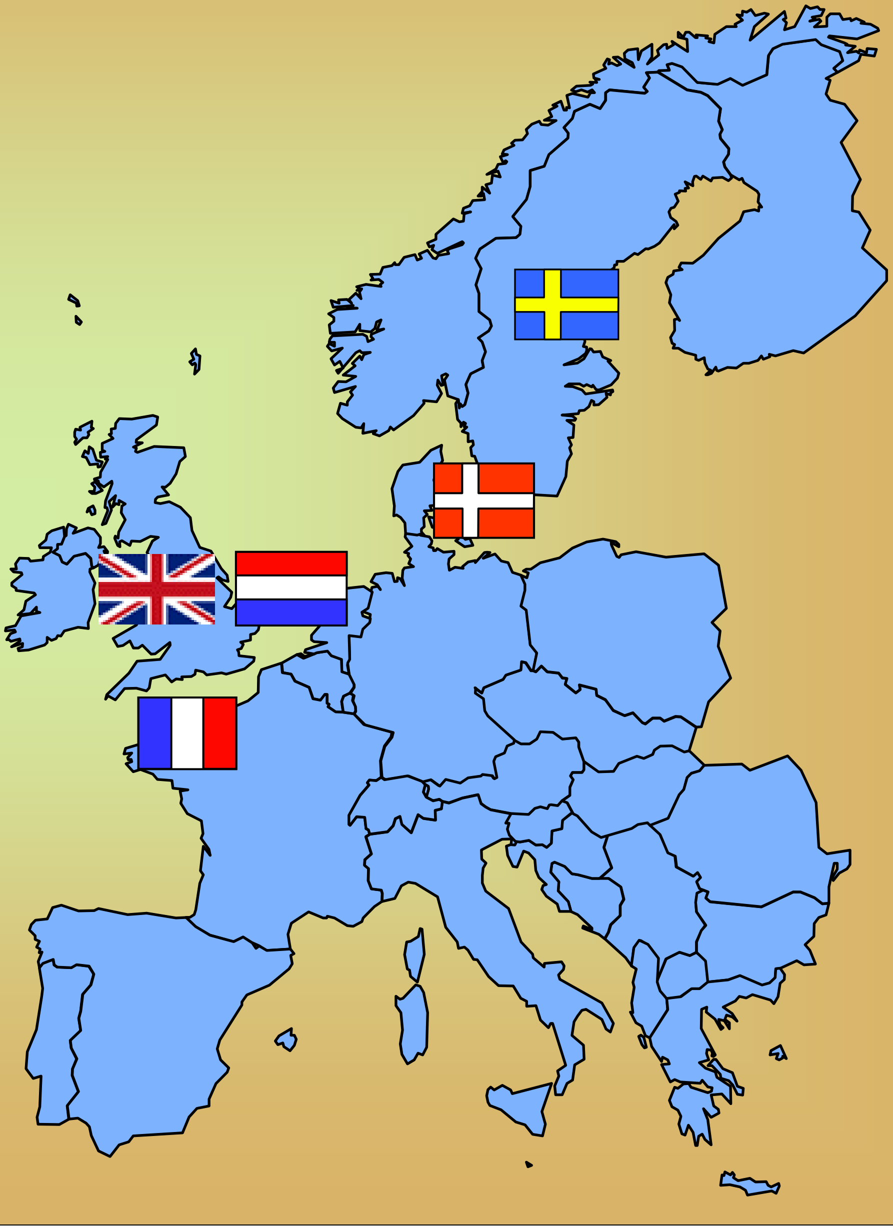
Consolidate Federation VV&A Products

Phase 7

- Collect all VV&A products and lessons learned.
- Assemble them into a VV&A package to support federation reuse.

VV&A Overlay to the FEDEP

REVVA



REVVA2 Project data

- Objective:
  - Produce a set of documents which will be proposed as a standard for a Verification, Validation and Accreditation methodology of data, models and simulations submitted to an appropriate international standardisation body
- Time frame: Jan. 2006 – Dec. 2008
- EUROPA MOU
- FR, CA, DK, NL, SE, UK (industry)

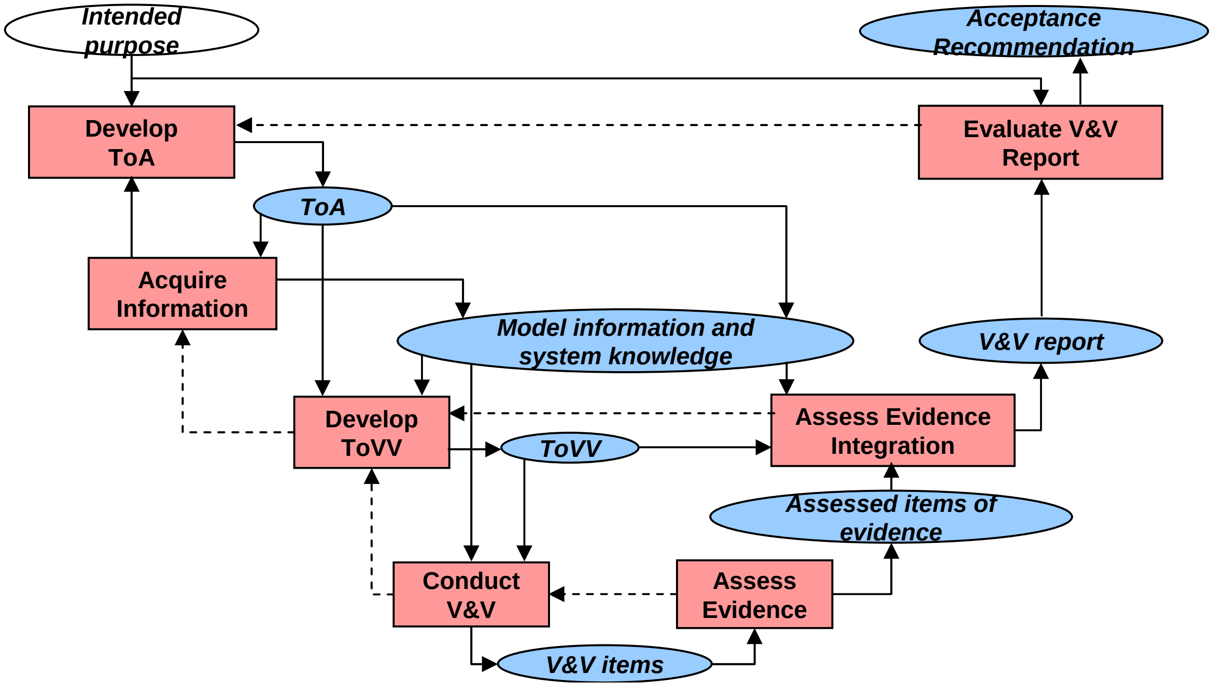
REVVA Process

- The VV&A process defines the logical and chronological flow of activities and products to facilitate the transition from the initial intended purpose, through a series of intermediate steps and products, to the final product, namely a report recommending/rejecting the use of the M&S product for the intended purpose.

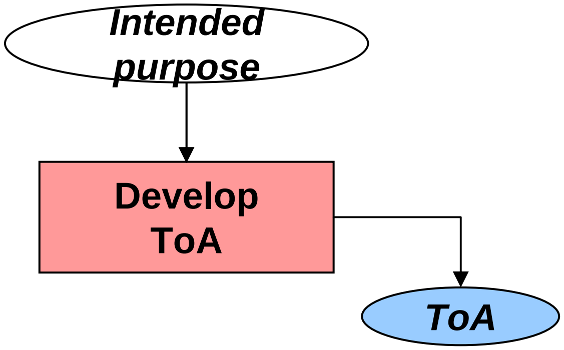
- The REVVA Generic Process supports product-oriented VV&A during or after model development (e.g., as required for reuse for another related intended purpose), and can be used as guidance for planning a VV&A effort.

REVVA Process

- The “V-Form” for the process representation was deliberately chosen, mirroring the preparation for V&V and the execution of the V&V activities on the left trunk (“\”) of the “V”, against the evaluation and the integration of the V&V results for the purpose of assessment on the right trunk (“/”) of the “V”.

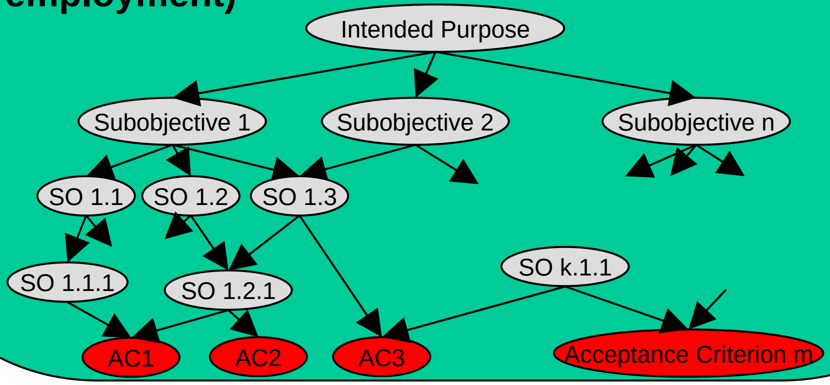


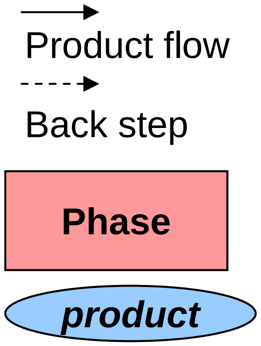
The REVVA process (1)



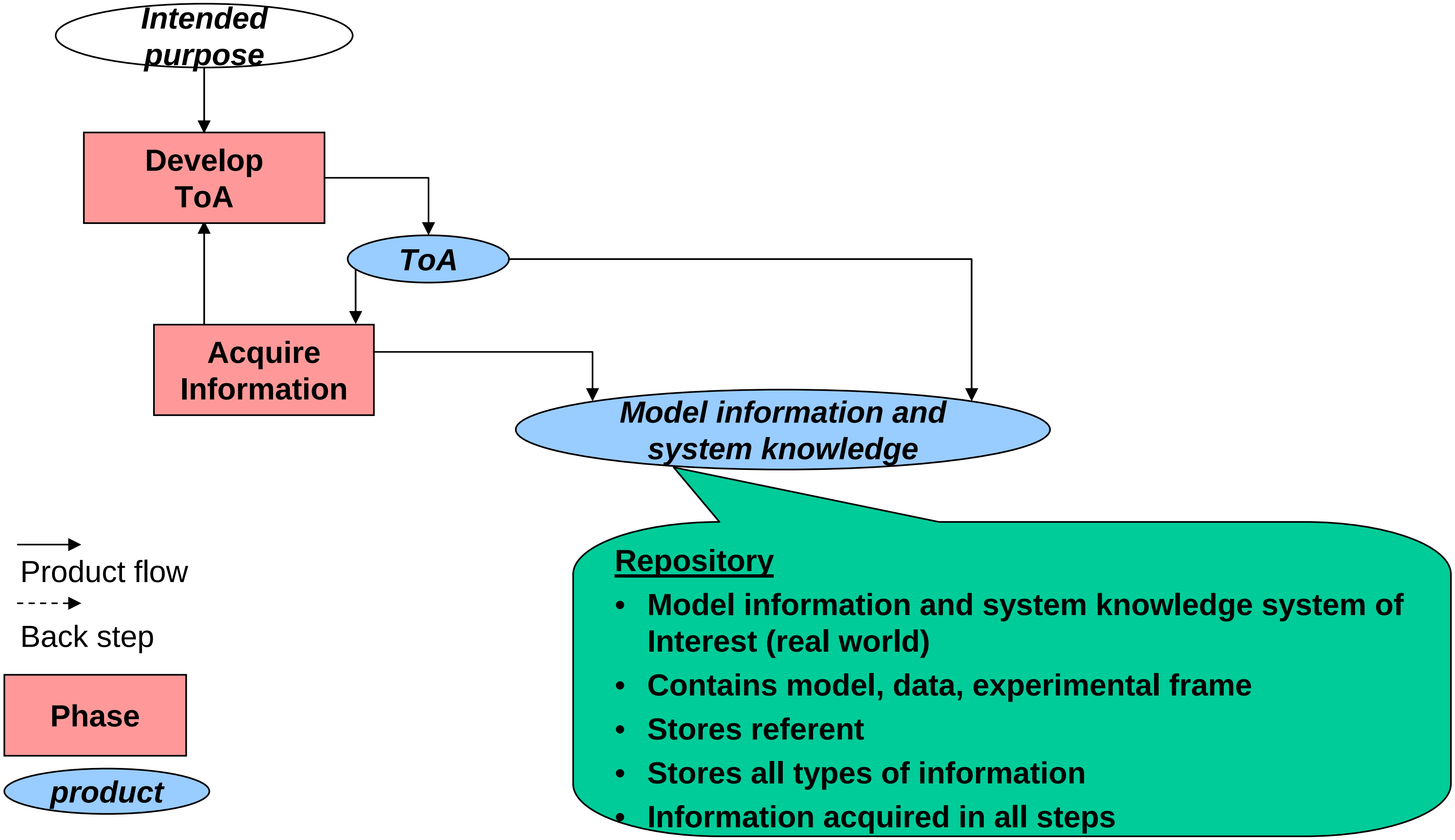
<u>Target Of Acceptance (contract)</u>

- **Detailed specification of the "intended purpose"**
- **Acceptance Criteria (AC) are derived**
- **passing the AC means fitness for purpose.**
- **A completely black box view of the simulation (but not of the simulation experimental use or employment)**





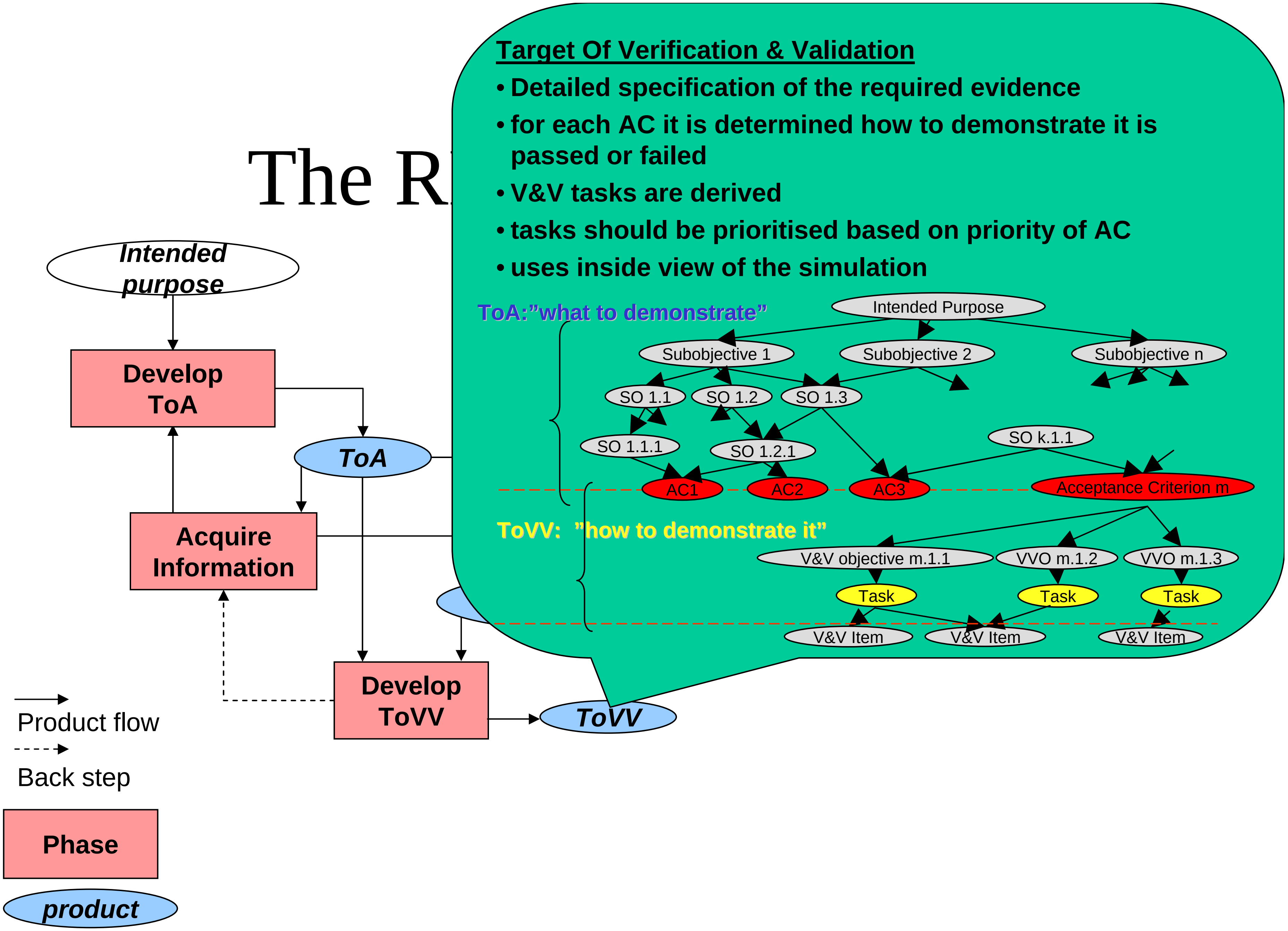
The REVVA process (2)



Repository

- **Model information and system knowledge system of Interest (real world)**
- **Contains model, data, experimental frame**
- **Stores referent**
- **Stores all types of information**
- **Information acquired in all steps**

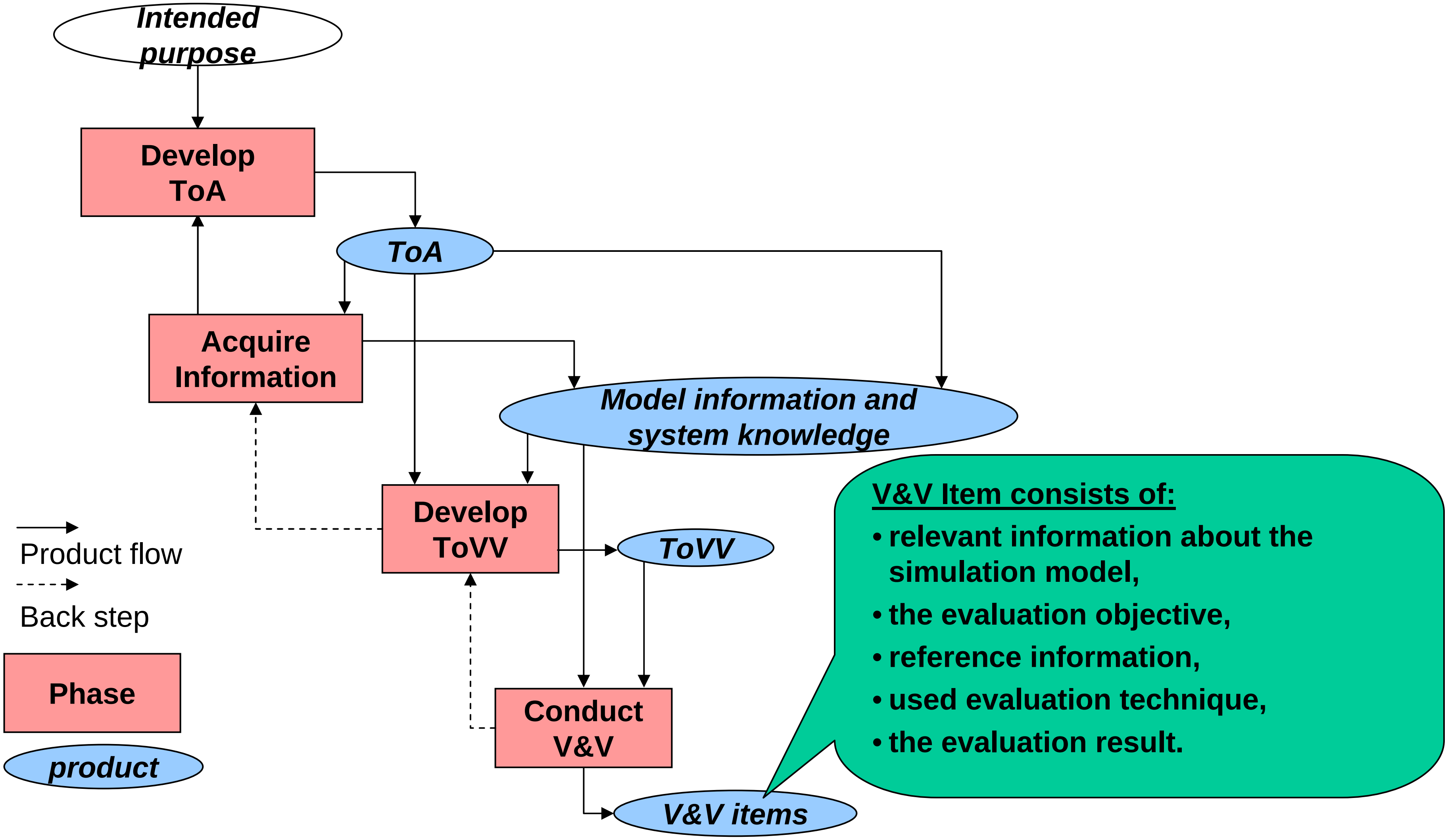
The R



Target Of Verification & Validation

- Detailed specification of the required evidence
- for each AC it is determined how to demonstrate it is passed or failed
- V&V tasks are derived
- tasks should be prioritised based on priority of AC
- uses inside view of the simulation

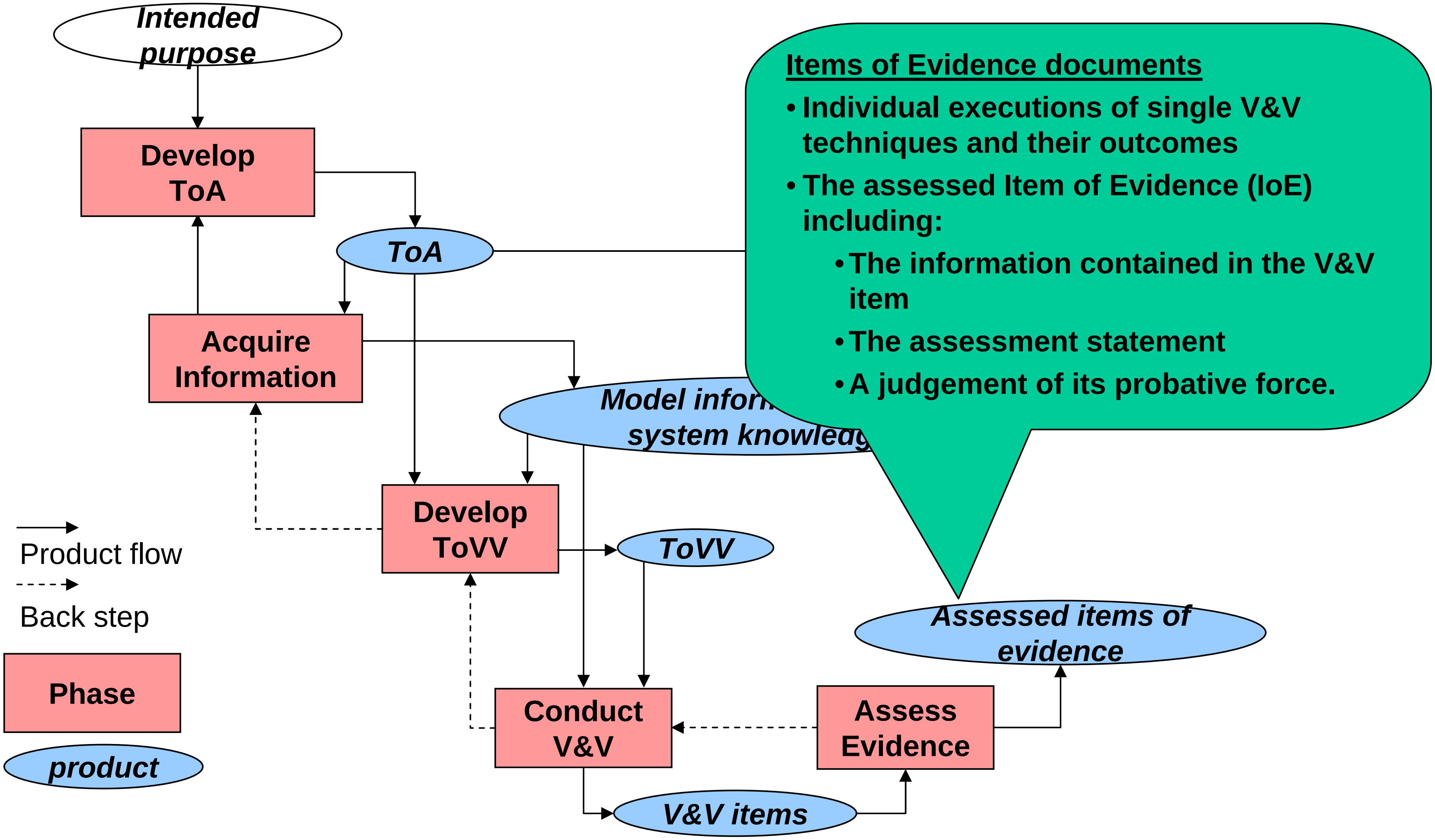
The REVVA process (4)



<u>V&V Item consists of:</u>

- **relevant information about the simulation model,**
- **the evaluation objective,**
- **reference information,**
- **used evaluation technique,**
- **the evaluation result.**

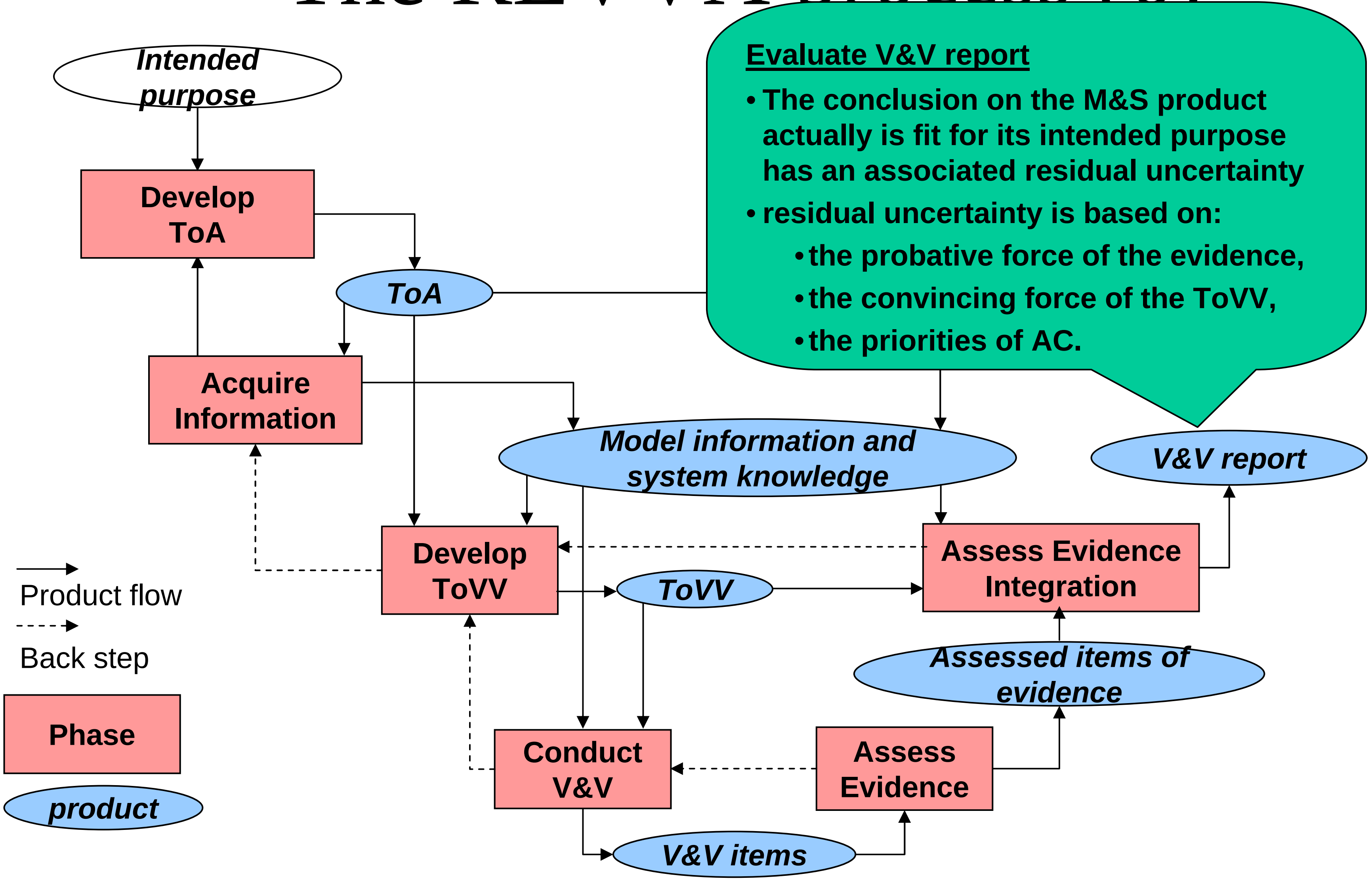
The REVVA process (5)



Items of Evidence documents

- **Individual executions of single V&V techniques and their outcomes**
- **The assessed Item of Evidence (IoE) including:**
  - **The information contained in the V&V item**
  - **The assessment statement**
  - **A judgement of its probative force.**

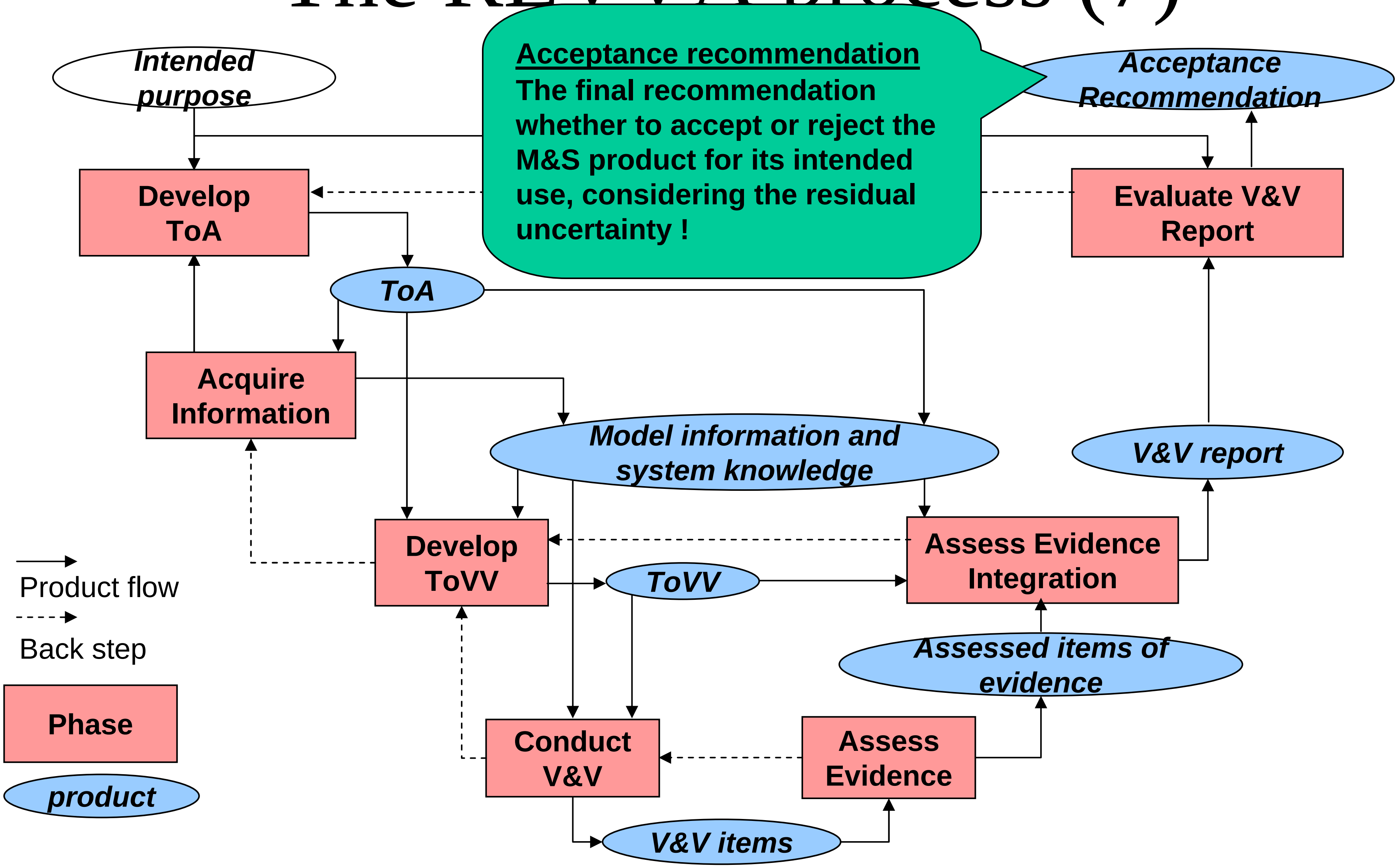
The REVVA process (6)



Evaluate V&V report

- The conclusion on the M&S product actually is fit for its intended purpose has an associated residual uncertainty
- residual uncertainty is based on:
  - the probative force of the evidence,
  - the convincing force of the ToVV,
  - the priorities of AC.

The REVVA process (7)



<u>Acceptance recommendation</u>

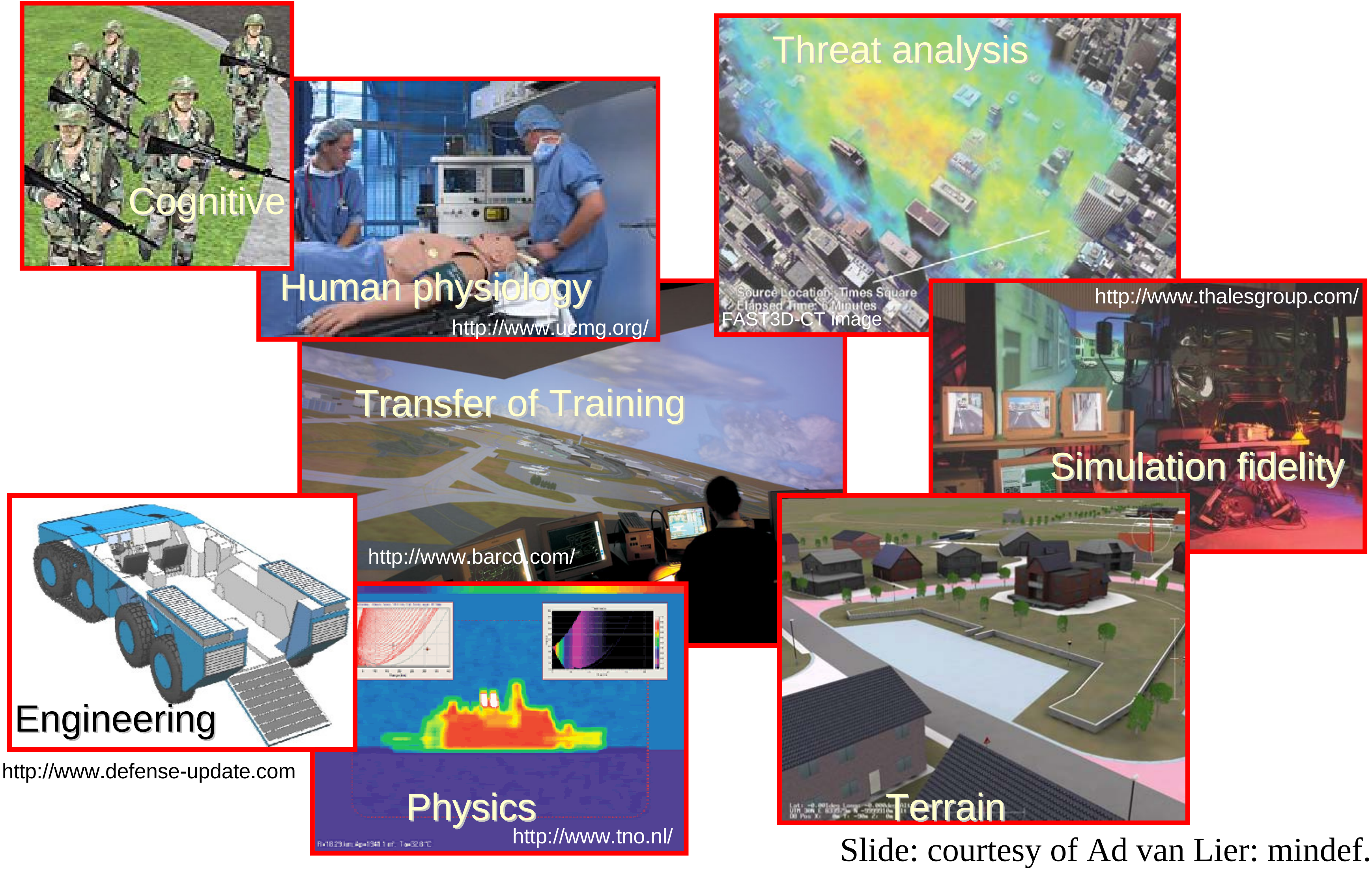
The final recommendation whether to accept or reject the M&S product for its intended use, considering the residual uncertainty !

SimulASCE tool

- UK industrial contribution to REVVA
- Based on established safety-domain tool
- Supports consistent text and graphic output
- Different specialised schema that support:
  - Deciding on ToA objectives
  - Planning V&V targets
  - Managing the V&V programme
  - Analysing and reporting V&V results

Generic Methodology for Verification and Validation (GM V&V) and Acceptance of simulations

GM V&V focus



http://www.bostondynamics.com

http://www.ucmg.org/

http://www.thalesgroup.com/

http://www.barco.com/

http://www.defense-update.com

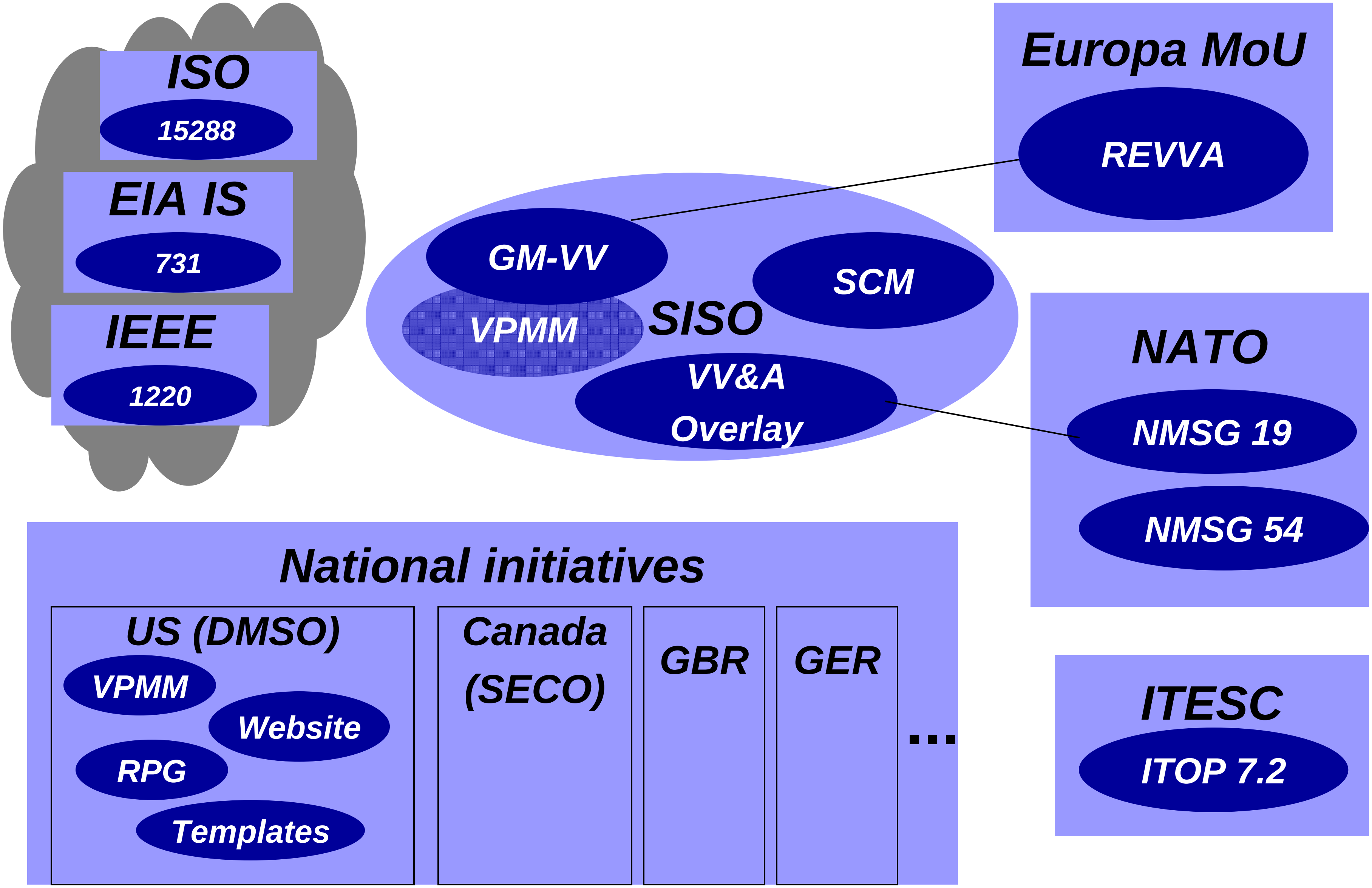
http://www.tno.nl/

Slide: courtesy of Ad van Lier: mindef.nl

SISO GM VV Product Development Group (PDG)

- Objective
  - is to provide a path for the creation of an internationally accepted VV&A standard complementing the current VV&A PDG efforts (dedicated to an Overlay of the FEDEP) and in consistency with the VV&A PDG efforts and other existing developments.
  - The final objective is to provide the international community with a methodology that not only embraces a wide variety of M&S products but also may provide a future common basis for the simulation community through the GM V&V product.

Identification of initiatives



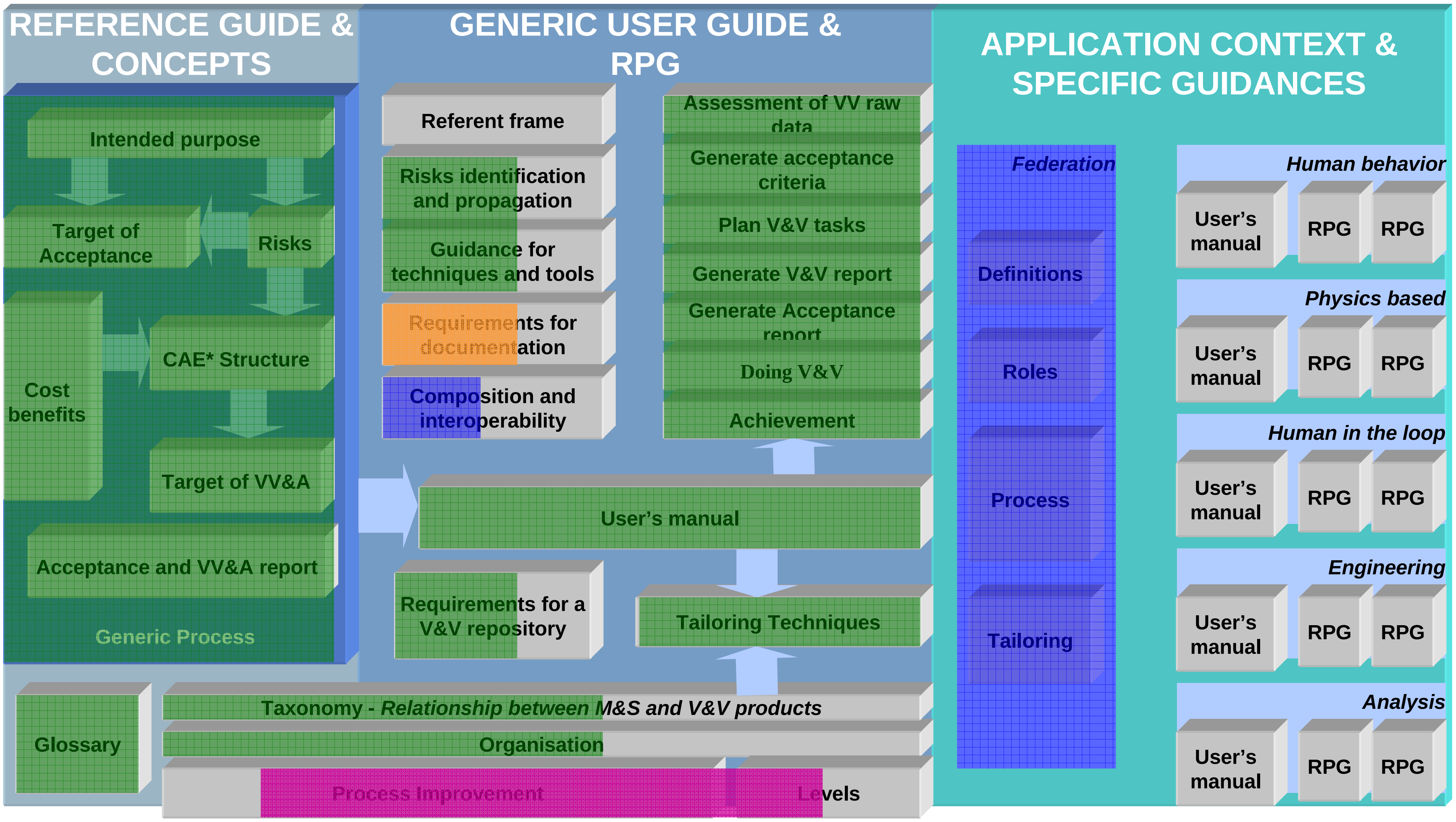
Global coverage VV&A standardisation products

REVVA

SISO

ITOP

VPMM



REFERENCE GUIDE & CONCEPTS

Intended purpose

Target of Acceptance

Risks

Cost benefits

CAE* Structure

Target of VV&A

Acceptance and VV&A report

Generic Process

GENERIC USER GUIDE & RPG

Referent frame

Risks identification and propagation

Guidance for techniques and tools

Requirements for documentation

Composition and interoperability

Assessment of VV raw data

Generate acceptance criteria

Plan V&V tasks

Generate V&V report

Generate Acceptance report

Doing V&V

Achievement

User's manual

Requirements for a V&V repository

Tailoring Techniques

Glossary

Taxonomy - *Relationship between M&S and V&V products*

Organisation

Process Improvement

Levels

APPLICATION CONTEXT & SPECIFIC GUIDANCES

Federation

Definitions

Roles

Process

Tailoring

Human behavior

User's manual

RPG

RPG

Physics based

User's manual

RPG

RPG

Human in the loop

User's manual

RPG

RPG

Engineering

User's manual

RPG

RPG

Analysis

User's manual

RPG

RPG

Conclusion

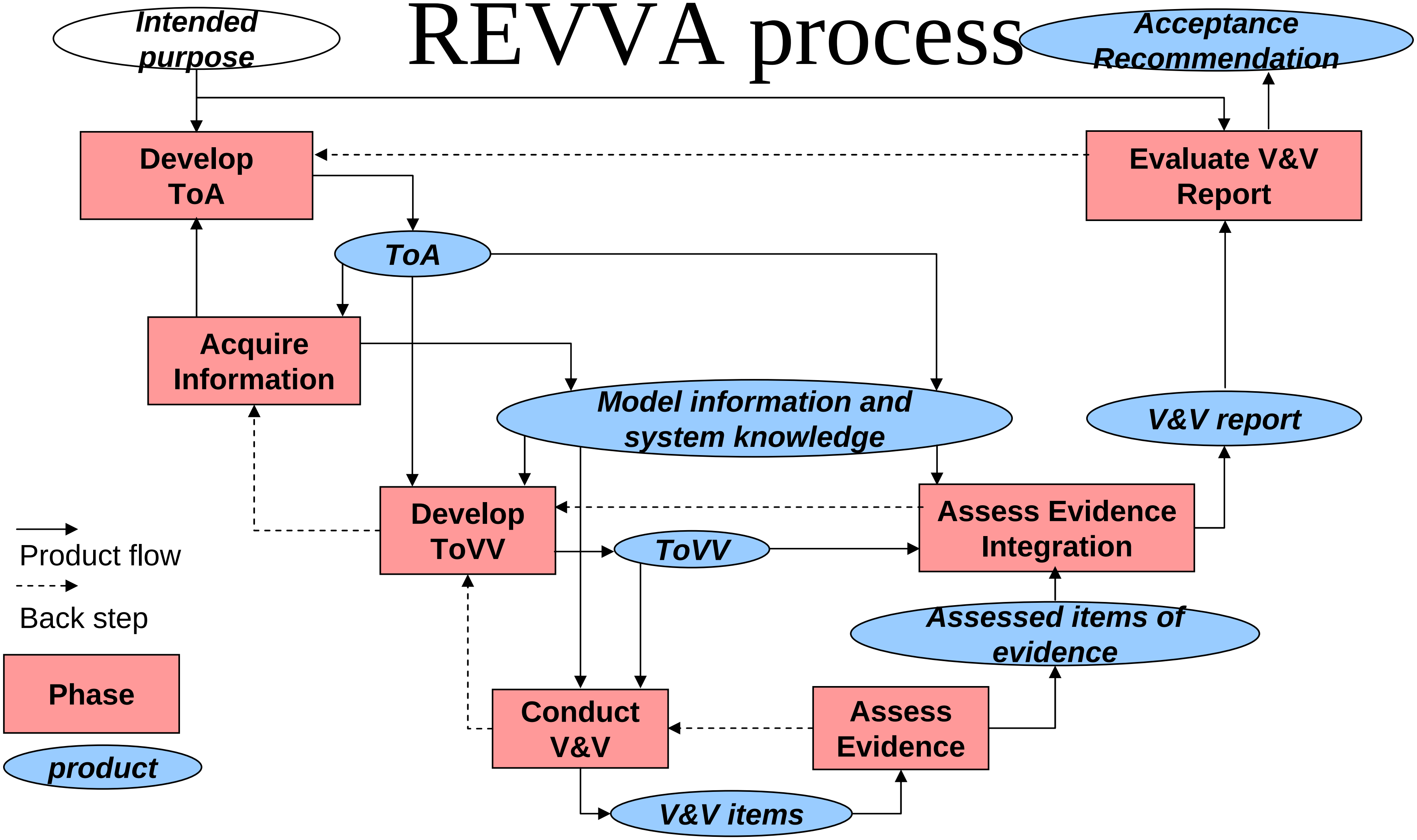
- Within the System safety domain, M&S is used an an enabling technology to facilitate problem solving and decision-making
- VV&A is intended to improve the confidence about the simulation results and to reduce the risk of using them
- International VV&A Initiatives (NMSG19/TG 16; REVVA 2; GM VV&A) recognizes the requirement for VV&A
  - Seeks to coordinate and collaborate VV&A activities to serve the greater M&S community

Acknowledgements

- The VV&A Overlay is the result of the collective contribution of the SISO PDG and NATO NMSG 19/ TG 16.
  - www.sisostds.org
  - www.rta.nato.int
- REVVA represents an international (European) contribution to VV&A
  - www.revva.eu
- GM V&V represents an international initiative to harmonize VV&A concepts, processes
  - www.sisostds.org

Questions

REVVA process



Intended purpose

Acceptance Recommendation

Develop ToA

Evaluate V&V Report

ToA

Acquire Information

Model information and system knowledge

V&V report

Develop ToVV

Assess Evidence Integration

ToVV

Assessed items of evidence

Conduct V&V

Assess Evidence

V&V items

Product flow

Back step

Phase

product