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New Perceptions in Coping with System of Systems (SoS)

Dr. Daniel Leshem

Corporate Chief Scientist

Rafael Armament Development Authority Ltd.,
Haifa, Israel

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New Perceptions in Coping with SoS

- SoS Definitions
- OSoS Characterizations, Parameters and Types
- Rationale for Defense Industry Entry in OSoS Development
- OSoSE Versus Systems Engineering
- OSoSE Recommendations
- OSoS Management Highlights

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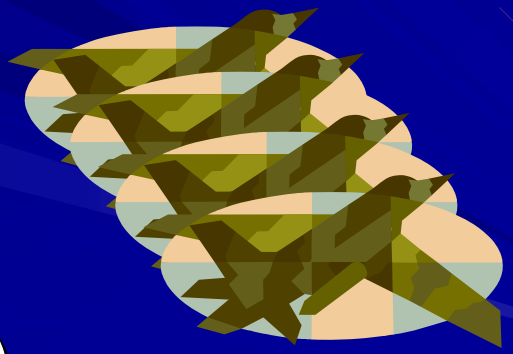
How to Define SoS?

- Family of Systems? Enterprise SoS? Complex System? or Super System?
- For example: one fighter aircraft incorporates many systems, but SoS refers to entire squadron!



- To be clear, I propose the term

Operational SoS (OSoS)

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Operational SoS Definition

Ensemble of platforms, armaments, equipment, C^4I, personnel, training and maintenance facilities.

These synergistically work together to achieve set of tasks within a defined mission, according to operational methodologies driven by combat doctrine

OSoS Example
FCS (Future Combat System)

- OSoS includes
  - Platforms
  - Weapons
  - C^{4}I2SR
  - Doctrine
  - Training facilities
  - Fighting Units
  - Soldiers
  - Maintenance
  - ILS
    (Integrated Logistic Support)

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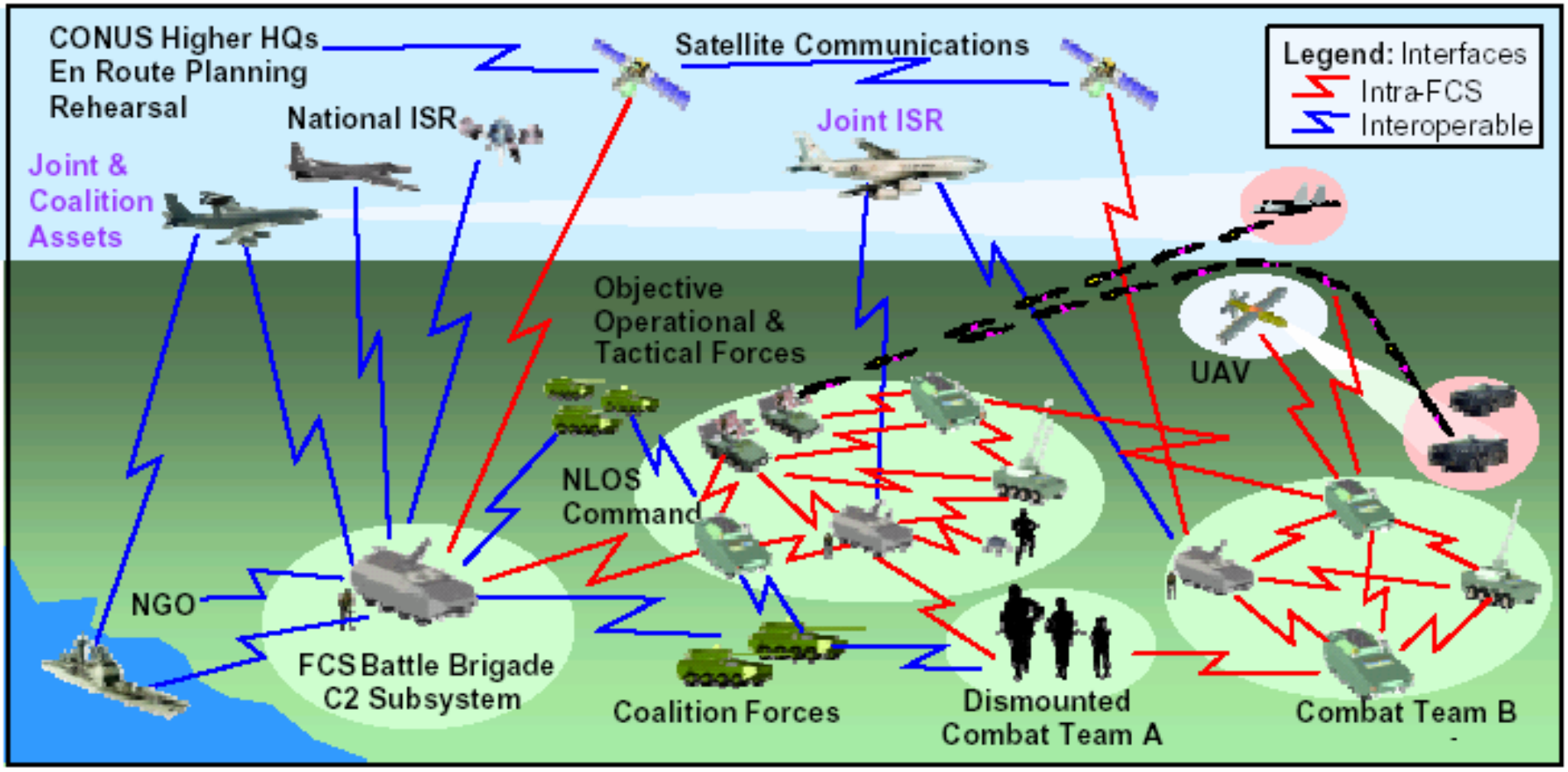
FCS OSoS - Concept of Operations



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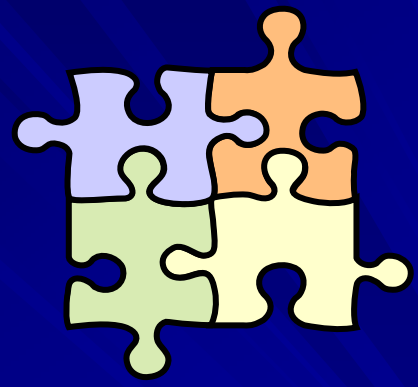
OSoS Characterizations

- Trained personnel are integral part of OSoS
- OSoS building blocks can be distributed at remote locations and interconnected by communication networks
- C^4I systems are critical "glue" for combining separate systems into OSoS

- Coordinated operation of all OSoS building blocks is key factor in effective and efficient mission accomplishment
- OSoS concept, architecture and capabilities are being consolidated in parallel with evolutionary development of its operational methodology

OSoS Types

- Dedicated vs Virtual OSoS



- Preplanned vs gradually-developed OSoS

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Rationale for Defense Industry Entry into OSoS Development

- Defense market customers new attitude is to deal with OSoS - defining requirements, evaluating and ordering OSoS - and not separate systems

- Many advantages for main contractor
  - Increasing reputation as leading defense industry
  - Enabling direct interaction with customers including End Users
  - Improving opportunity to incorporate own advanced technologies
  - Improving own capabilities when coping with OSoS Systems Engineering (OSoSE)

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OSoSE vs Systems Engineering

- Starting OSoS Program
- Requirements consolidation and management
- Functional Analysis
- Interfaces definition
- Modeling and Simulation
- Defining and executing V&V
- Evolutionary behavior of OSoS
- Architectural analysis of OSoS
- Deep involvement of interested parties

OSoSE vs Systems Engineering

- Starting OSoS Program
- Requirements consolidation a[illegible]gement
- Fun[illegible]
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  - Very long processes together with interested parties and customers to refine concept
  - Early consolidation of Strategic Partners
  - Considerations of using state-of-the-art or just Foreseen Technologies
  - Starting interim developments to reduce risks and/or to verify new concept (usually the proven concepts become constraint in the full scale program)

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OSoSE vs Systems Engineering

- Starting OSoS Program
- Requirements consolidation and management
-
  - Very high level of complexity in consolidating requirements for new OSoS:
    - many customers with different interests,
    - evolutionary nature of development, and
    - necessity for interoperability
  - Requirements develop and are updated during entire OSoS life cycle
  - Connectivity and interfaces with neighboring OSoS under development
  - Advanced software tool is needed to handle the huge requirements scope (the original + derived ones) and their complex linkages

OSoSE vs Systems Engineering

- Starting an OSoS Program
- Requirements consolidation and management
- **Functional Analysis**
- Interfaces defi[illegible]
- Modeling [illegible]
- Defini[illegible]
- Evolu[illegible]
- Archi[illegible]
- Deep [illegible]

- **Processes, tasks and scenarios in OSoS are complex, involving many components**
- **These create interactive constraints and mutual effects**
- **Conclusion: Methodical Functional Analysis is critical for architectural consolidation of OSoS**

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OSoSE vs Systems Engineering

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- **Systems Engineering defines mechanical, electrical, computational - connectivity and MMI interfaces**
- **OSoS provides upper layer of different types of scenarios and tasks: Physical: different configurations and Logical: different tasks**
- **Result: Different interface requirements for various applications**

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OSoSE vs Systems Engineering

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- **Not possible to produce complete model of OSoS to simulate all its functionality as:**
  - **Infinite cases of possible events and scenarios included**
  - **Very difficult to simulate human behavior**

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OSoSE vs Systems Engineering

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- Deep involvement of int

These situations require:

- **Using many models to cover all hierarchy levels**
- **Simulating tasks management with Humans-in-the-Loop**
- **Developing special simulation concepts and tools to cope with OSoS**

Example: GES4

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OSoSE vs Systems Engineering

- Starti
- Requ
- Func
- Interfa
- **Modeling & Simulation**
- **Defining and executing V&V**
- **Evolutionary behavior of OSoS**
- **Architectural Analysis of OSoS**
- **Deep involvement of interested parties**

- **Complex V&V procedures: analysis, simulations, integrations and tests**
- **Verification of the design in stages, combined with risk analysis and plans**

OSoSE vs Systems Engineering

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- **Complex V&V procedures: analysis, simulations, integrations and tests**
- **Verification of the design in stages, combined with risk analysis and plans**

- **Interfaces verification at all levels, scenarios and tasks**
- **OSoS validation in series of high-level preplanned test scenarios**

OSoSE vs Systems Engineering

- **OSoS Life Cycle Concept:** taking into account existing systems, future development and stages in life cycle and life time
- **Adaptive development:** considering unexpected changes in directions as result of operational lessens learned by early fielded models
- **Development environments:** as teams, subcontractors, knowledge, experts, tools – **are changing!**
- Evolutionary behavior of OSoS
- Architectural Analysis of OSoS
- Deep involvement of interested parties

OSoSE vs Systems Engineering

- **Definition: Model description (physical, functional, operational, software etc) at OSoS upper level in its relevant environment, considering its evolutionary and open system natures**
- **Architectural Analysis of OSoS require very high level of professionalism in following issues:**
  - **Methodology**
  - **Tools**
  - **Training**
  - **Experts**
- **Evolutionary behavior of OSoS**
- **Architectural Analysis of OSoS**
- **Deep involvement of interested parties**

OSoSE vs Systems Engineering

- Range of interested parties usually with contradictory interests! - including main contractor and subcontractors, customers taking part in development and end users
- OSoS military aspects require close involvement of customer as early as possible with professional teams who can make difficult decisions!
- Close cooperation with customer and mutual obligations are essential for successful building of OSoS!

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- Architectural Analysis of
- Deep involvement of interested parties

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OSoSE Recommendations

- Methodology
  - New special upper level of Systems Engineering Process to be defined (V model recommended)
  - Interoperability and MOSA (Modular Open System Approach) in OSoS to be adopted
  - Professionalism of OSoS Architecture and function of Chief Architect (compared to Chief Systems Engineer) to be cultivated

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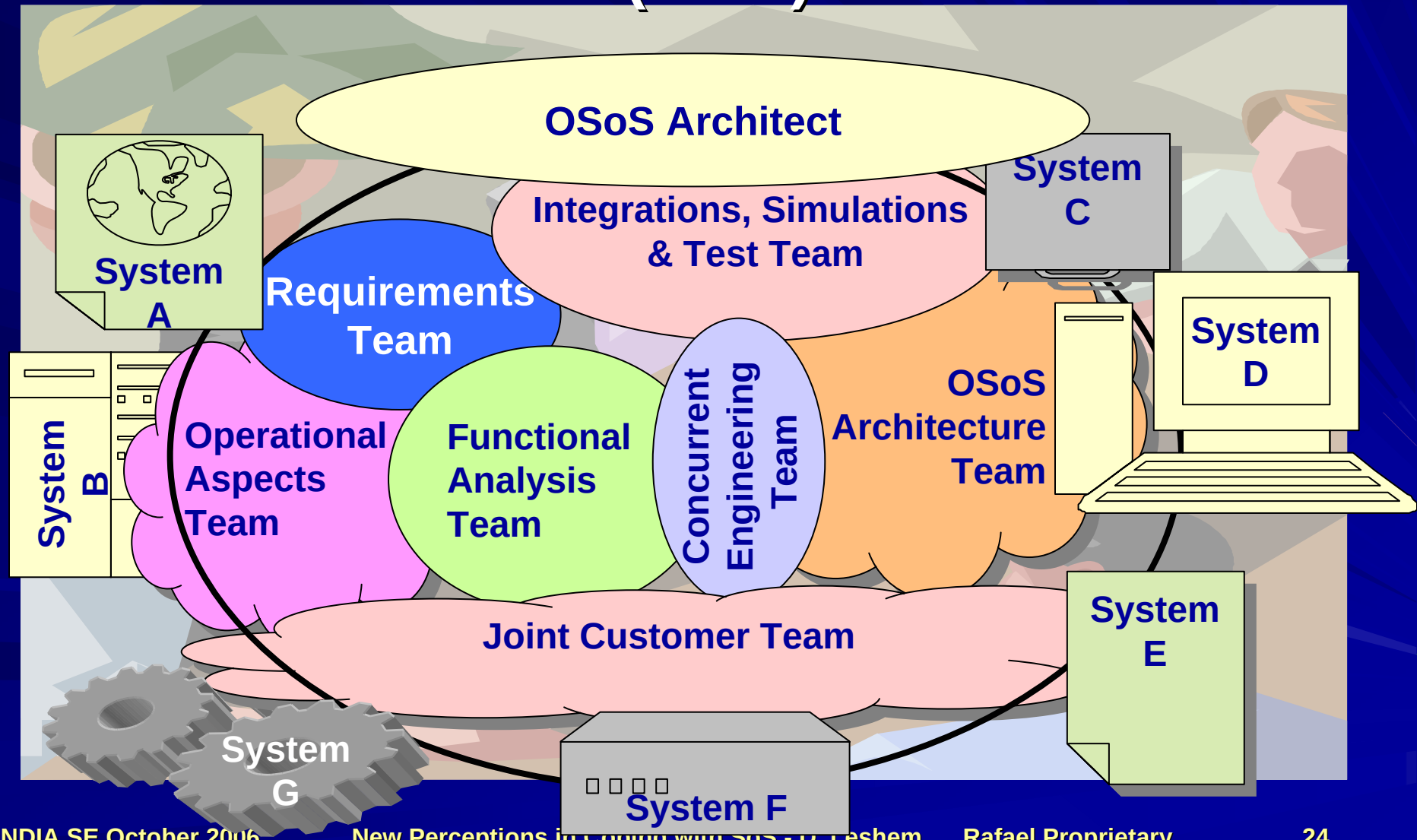
OSoSE Recommendations

- Organization
  - Chief Architect, responsible for all aspects of OSoS Engineering, directly subordinate to Program Manager/Management
  - Working with Integrated SE Team (ISET)

Integrated SE Team for OSoS (ISET)



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OSoSE Recommendations

- Tools
  - Central database
  - Creating and preserving logical connections with full traceability
  - On-line coordination between all development bodies
  - Automatic documents production
  - Fast transformation from UC analysis to working software implementation
  - Massive supportability
    - Examples: Core, Requisite Pro, Clear Case, Rhapsody, Doors

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OSoSE Recommendations

- **Critical technology disciplines and infrastructure required for OSoSE**
  - **Information (collecting, processing, distribution)**
  - **Intelligence (collecting, decoding, data fusion, processing, distribution)**
  - **Sensing (electro- optical, acoustics, RF,…)**
  - **C^4I2SR**
  - **Interdisciplinary and multidisciplinary know-how such as:**
    - **Image processing with navigation**
    - **Communication with missile guidance, control and navigation**
    - **Intelligence with signal processing, pattern recognition;**
    - **and more…**

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OSoS Managements Highlights

- Coping with OSoS provides main contractor with many advantages and benefits - and it's worth it!
- Spiral development of OSoS ensures use of most updated technologies and capabilities available while dealing with enemy emergent threats, in process that allows step-by-step fielding

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OSoS Management Highlights

- Recommended to manage OSoS architecture and systems engineering processes through Chief Architect and Integrated SE Team
- Use specific gates and checklists as necessary management tool in building OSoS
- Common methodologies, tools and Infrastructure for all parties and bodies involved in development of OSoS is key to success!

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New Perceptions in Coping with OSoS
Summary

- OSoS (Operational SoS) is proposed as common term to which Defense industry can refer
- New level of complexity - not just “more” regular Systems Engineering – it requires development of new concepts, approach and methodologies
- It’s a challenge!
- It’s worth it!

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Dr. Daniel Leshem
Corporate Chief Scientist
Rafael – Armament Development Authority Ltd., Israel
dleshem@rafael.co.il

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ARMAMENT DEVELOPMENT AUTHORITY Ltd.

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Speaker background:

Daniel Leshem

B.Sc. (1969, *Cum Laude*), and **M.Sc.** (1976) in Aeronautical Engineering, Technion -Israel Institute of Technology.

Ph.D. in Aeronautics & Astronautics, 1985, Stanford University, California, USA. (Thesis: "Composite Barriers and Corner Conditions in Differential Games")

Rafael – Armament Development Authority Ltd., Israel:

Since 1969: group leader, systems engineer, chief engineer, manager of Antitank missile directorate, VP for R&D, VP Chief Systems Engineer, Corporate Chief Scientist

GE Medical Systems, Israel (NM): VP for R&D (1997-1999)

Prize: Israel National Defense Prize (1984)

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- C4I2SR
  - Command Control, Communication, Computers
  - Intelligence, Information
  - Surveillance
  - Reconnaissance