Module 9: The System Integration State

Version 1.12.13

Objectives

- For this state of the SDP
  1. To identify
     - the role of systems engineers
     - the nature of the problems they face
  2. To introduce
     - the tools, methodologies and techniques available to solve those problems.
  3. To develop an outline system intragation plan

Contents

1. The role of systems engineers in the System Integration State of the SDP
2. The nature of the problems faced in the state
3. The tools, methodologies and techniques available to solve those problems
4. The critical applied systems engineering tasks which systems and software engineers must perform in these states
5. Awareness of the factors involved in the intragation of components into a system
6. Integration of a system into its adjacent systems
7. Design for integration
8. Problem solving across subsystem boundaries

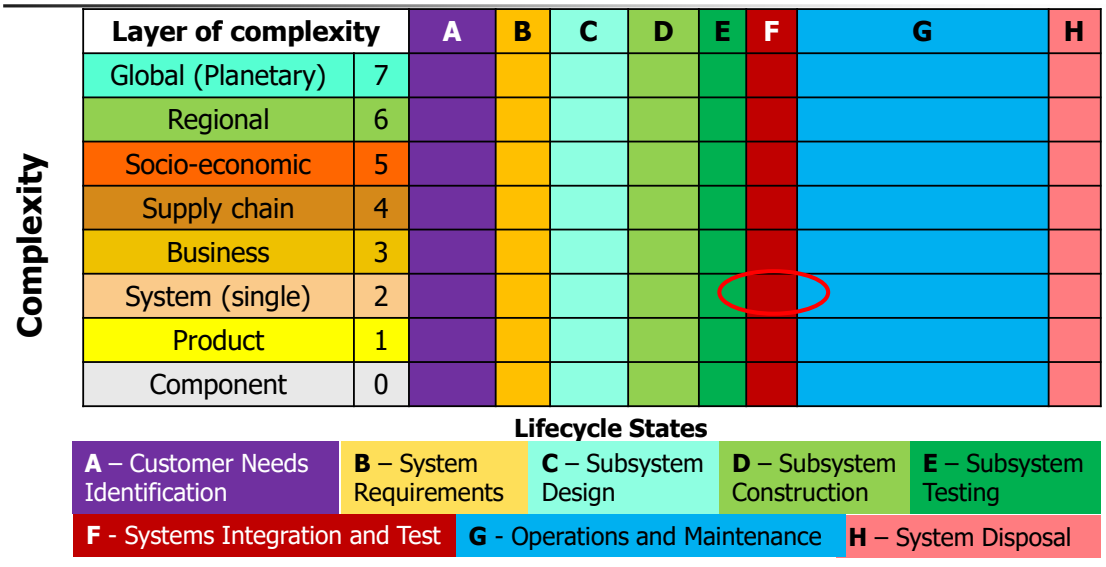
Topics

- Awareness of the factors involved in intragation of components into a system.
- Integration of a system into its adjacent systems.
- Design for integration.
- Problem solving across subsystem boundaries.
- Interface and change management.

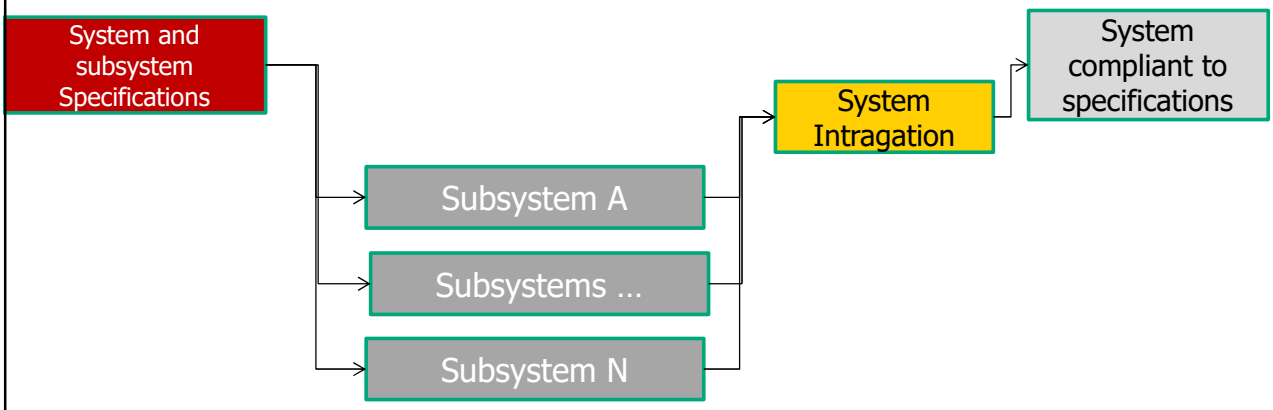
Knowledge component

- Lecture
  - Sets the context
  - Integration of a system into adjacent systems
  - Intragation of subsystems (components) into a system
- Readings
  - 0902 Systems Engineering Chapter 14: The System Integration and Test States of the SDP.
  - 0903 Systems Engineering Chapter 17 The nuts and bolts of systems.
  - 0904 "The nuts and bolts of systems", expanded video at https://youtu.be/32eejWkyM1E
  - 0905 Systems Integration: A Complex Challenge, Podcast at https://youtu.be/eb_Rap9DqN0
  - 0906 Hetherington, D., Systems Integration: A Complex Challenge, INCOSE Sector III Speaker Series in December 2024 recording at https://vimeo.com/1039097643/730b13a386?ts=0&share=copy
  - 0810 Applying TQM to Systems Engineering, Chapter 17: The Design, Build, Integrate and Test States (same as last Module) alternative to 0902
- Exercises

Big Picture



SDP phased activities (HKMF F)



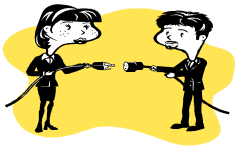
Definitions

- **System integration**
  - is the assembly of the subsystems into the system
  - is also the integration of the system into its adjacent systems
- For this module
  - Systems integration – integration of the system with its adjacent systems
  - System intragation* - integration of the subsystems into the system
  - System int_gation* - integration and intragation

* Invented word for this module for discussion of topic from external perspective

Systems Integration

- Integrate new system into existing systems
  - Compatibility and interoperability
  - Provision of additional functionality
  - Replacement of existing functionality
- Schedule aspects
- Emergent properties
- Problems due to poor engineering surface

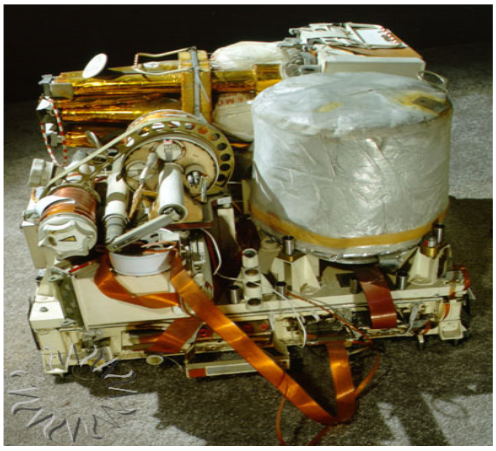


Software intragration

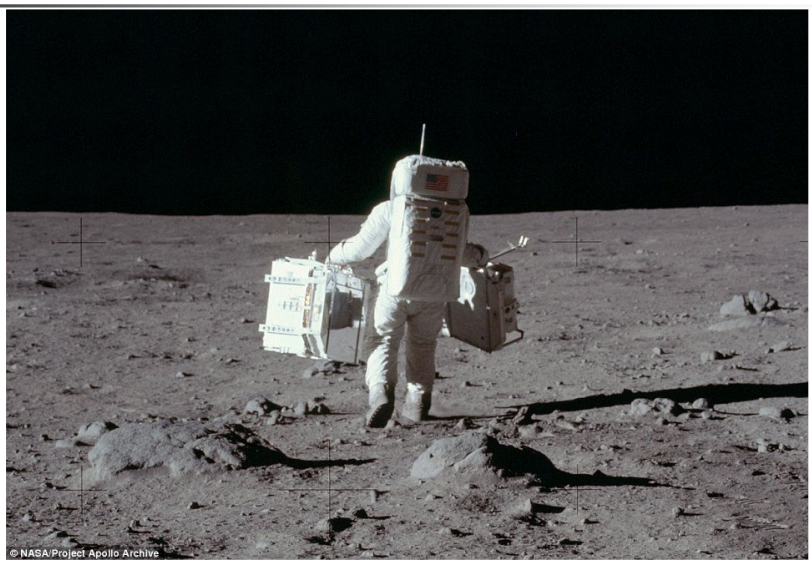
- Prerequisite
  - Software units (subsystems) tested prior to intragation
  - Test criteria
  - Software unit compiles without error
- Result
  - Possible problems
    - Could be in unit
    - Could be in interaction between units
- Important to monitor subsystem testing

Systems Intragation

- Intragate components of a single system to create the system
- Design for intragation and test
  - COTS or Custom?
- Order of intragation of components
- Testing aspects
- After SRR
  - Monitor problems and resolve for optimal system performance
  - Test and evaluation activities w.r.t. systems issues

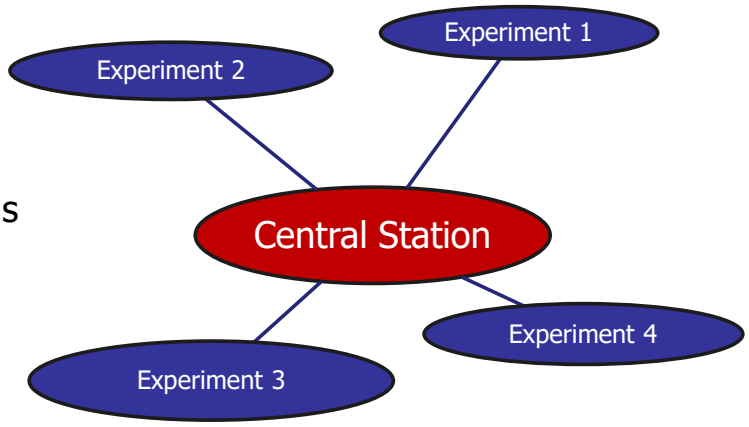


Carrying the ALSEP to deployment location



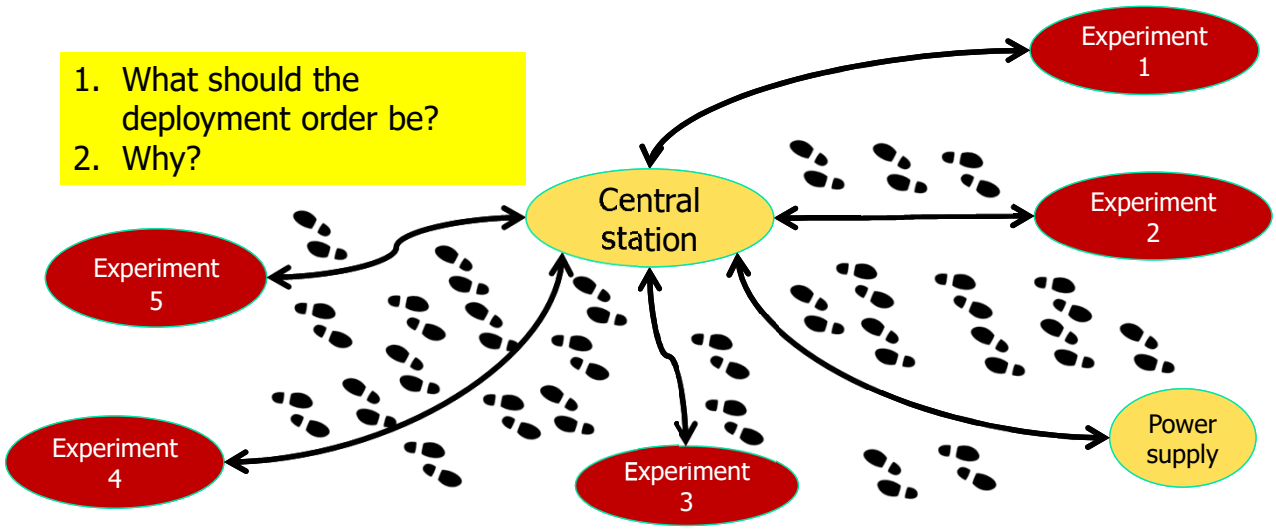
ALSEP deployment

- Unpack from palette shown in previous slide
- Locate experiments on surface per plan
- In a sequence that avoids stepping over a connected cable



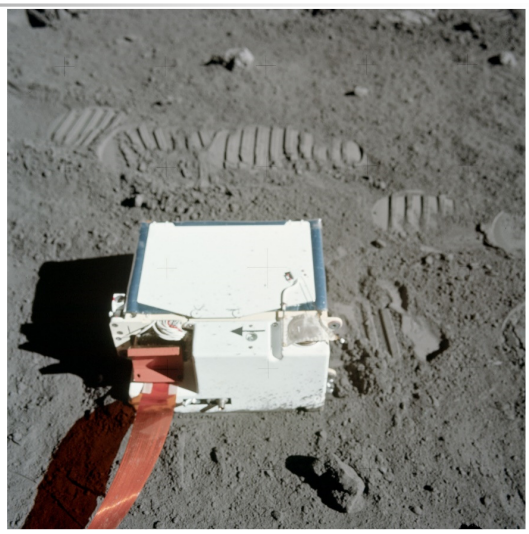
ALSEP deployment?

1. What should the deployment order be?
2. Why?



Astronaut broke a cable

- Tripped on cable and broke it
- Risk, if identified
  - High severity of impact
  - Low probability of occurrence ?
  - Users of traditional risk matrix would ignore the risk
- Problem
  - How to repair the cable?



Astronaut broke a cable

- Tripped on cable and broke it
- Risk, if identified
  - High severity of impact
  - Low probability of occurrence ?
  - Users of traditional risk matrix would ignore the risk
- Problem
  - How to repair the cable?
- Constraint
  - With equipment on the moon
- Solution
  - Could not be achieved in time

ALSEP Start up problem in intragation test

- Context
  - Testing the second unit
  - Domain knowledge
    - Electronics take a finite time to settle down after power is switched on
- Symptom
  - Experiments powered up in different states each time the system was turned on
  - Had not happened on the first unit
- Undesirable
  - Some experiments contained pyrotechnic devices
  - One of those states could cause an explosion
  - Hazard to astronaut

Investigation

- Cause
  - Spikes on interface
    - Electrical TTL logic
  - Unspecified TTL transient behaviour during power up
  - Experiments and Central Station (CS) power stabilize at slightly different times
- Solution
  - Add delay components to CS to prevent spike from happening

Emergent properties

Show up during system intragation

- Known
  - Desired
    - Purpose of system
  - Undesired
    - May become
      - Don't care
  - Don't care
    - Ignore
- Unknown
  - Undesired
    - Prevented or mitigated
    - May cause redesign or cancellation
  - Desired when noticed
    - May cause change to operations concept and requirements
  - Don't care when noticed
    - Ignore but make sure they can be ignored

Problem solving across subsystem boundaries

- E.G. Undesirable situation in one subsystem may be remedied by a change in another subsystem
  - Subsystem A is overweight by W
  - Systems analysis of problem shows subsystem B is underweight by W + w
  - Remedy – change specs on subsystem A and B but ensure system spec on weight does not change
- BTW, this should have been picked up and remedied during subsystem construction state

Problem solving across subsystem boundaries

- Interfaces do not work as specified, e.g.
  - Electrical
    - Signals have incorrect modulation, data, phase, etc.
  - Mechanical
    - Screw holes in wrong place, or wrong size, thread, etc.
    - Incompatible connectors
  - Thermal
    - Insufficient cooling
- BTW, these should have been picked up and remedied during subsystem construction state or even earlier

Role of systems engineer in Int_gation process

- Pre SRR
  - Requirements management and engineering
    - Including Integration/Intragation requirements based on Integration/Intragation scenarios in the CONOPS
      - Supply chain requirements
      - Assembly requirements
  - Problem identification and resolution
  - Design for int_gation
- Post SRR
  - Interface management and engineering
  - Change management and engineering
  - Problem identification and resolution
  - Dealing with undesired emergent properties
  - Developing int_gation plans

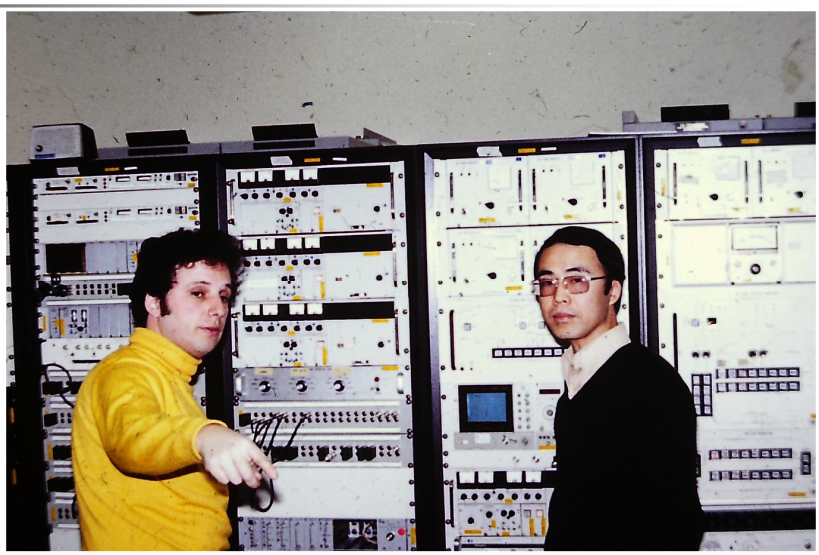
Approaches to int_gation

1. Phased
   - Combine subsystems one at a time, testing along the way
   - Various approaches – functional, physical
2. Big bang
   - Connect the system and then test

- Each approach presents different problems

System int_gation

- Intragated and system tested at Comsat
- Re-intragated on-site at Yamaguchi
- Integrated with adjacent systems
  - Power
  - Antenna controller



Tools for systems int_gation

- Configuration control
- Problem tracking
- Jigs
- Test equipment
- Same set as for the requirements state

Exercise 9-11

1. Develop a "systems intragation plan" presentation for the sequence of intragation of the structural/physical components of the HEADS into a system
2. Prepare a <5 minute presentation:
    1. This slide and the version number of the session
    2. Problem formulated per COPS problem formulation template
    3. Compliance matrix
    4. Summary of the plan
        - Demonstrating use of GANT and PERT Charts
        - FRAT and SPARK and their relationship
    5. Lessons learned
3. Save as a PowerPoint file in format Exercise9-11-abcd.pptx
4. Upload to Asynchronous group

Knowledge reading exercise 9-12

1. Prepare a brief on two main points in reading/video 0903/0904 (< 5min)
2. Presentation to contain
    1. Formulated problem per COPS problem formulation template
    2. A summary of the content of the reading (<1 minute)
    3. The compliance matrix
    4. This slide and the version number of the lesson
    5. The two main points (<1 minute)
    6. Brief on one main point (<1 minute per point)
    7. Reflections and comments on reading (<2 minute)
    8. Comparisons of content with other readings and external knowledge
    9. Why you think the reading was assigned to the module
    10. Lessons learned from module and source of learning e.g. readings, exercise, experience, etc. (<2 minutes)
3. Save as a PowerPoint file as Exercise9-12-abcd.pptx
4. Upload to Asynchronous group

Knowledge reading exercise 9-13

1. Prepare a brief on two main points in podcast 0905/0906 (< 5min)
2. Presentation to contain
    1. Formulated problem per COPS problem formulation template
    2. A summary of the content of the reading (<1 minute)
    3. The compliance matrix
    4. This slide and the version number of the lesson
    5. The two main points (<1 minute)
    6. The two briefings
    7. Reflections and comments on reading (<2 minute)
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Summary

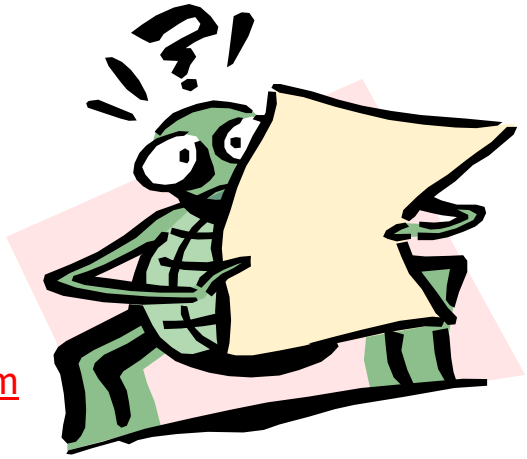
- Awareness of the factors involved in
  - intragation of components into a system.
  - integration of a system into its adjacent systems.
- Design for int_gation.
- Problem solving across subsystem boundaries.
- Interface and change management.

Meeting the objectives

- For this state of the SDP, we
  1. Identified
     - the role of systems engineers
     - the nature of the problems they faced
  2. Introduced
     - the tools, methodologies and techniques available to solve those problems.
  3. Developed an outline system intragation plan

Any questions ?

1. Best
2. Worst
3. Missing



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