Human Systems Integration: Definitions, Evolutions, and Applications

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Agenda

- Definitions of HSI and HSI Domains
- Relationship of HSI to SE
- Checkpoint #1: Impressions of HSI?
- HSI Case Studies and Trends
- Checkpoint #2: Project Experiences
- Take-aways

What is HSI?

cultural anthropology

product design

cognitive engineering

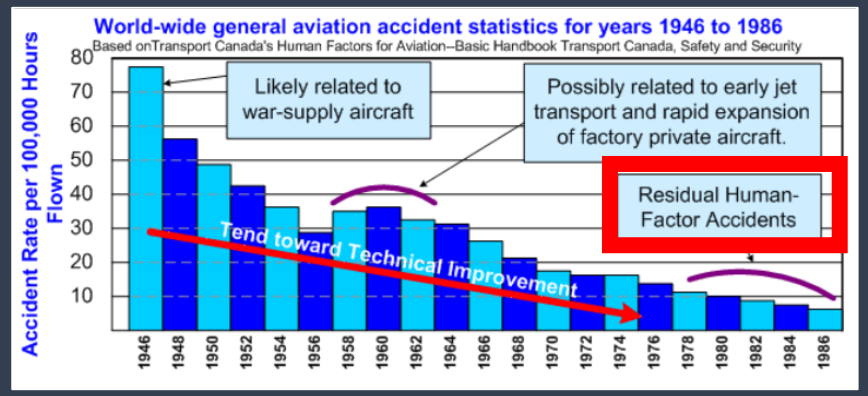
Human-Systems Integration

For a quick history, see: https://www.bresslergroup.com/blog/user-research-and-interaction-design/

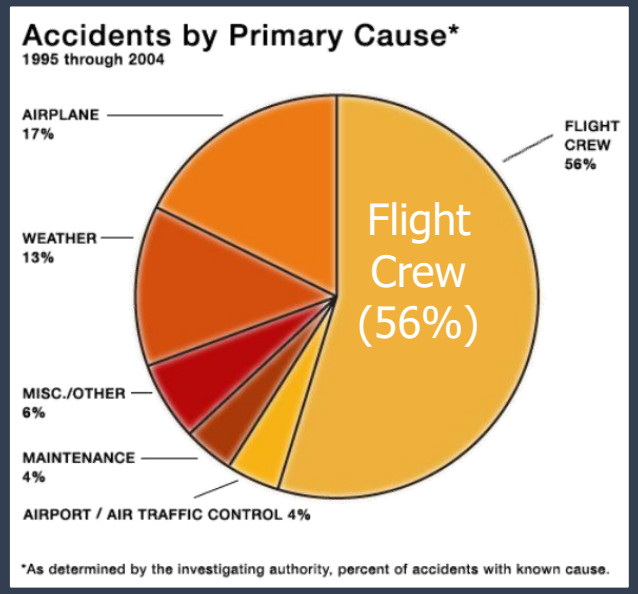
What are some terms that you've heard?

When is HSI needed?

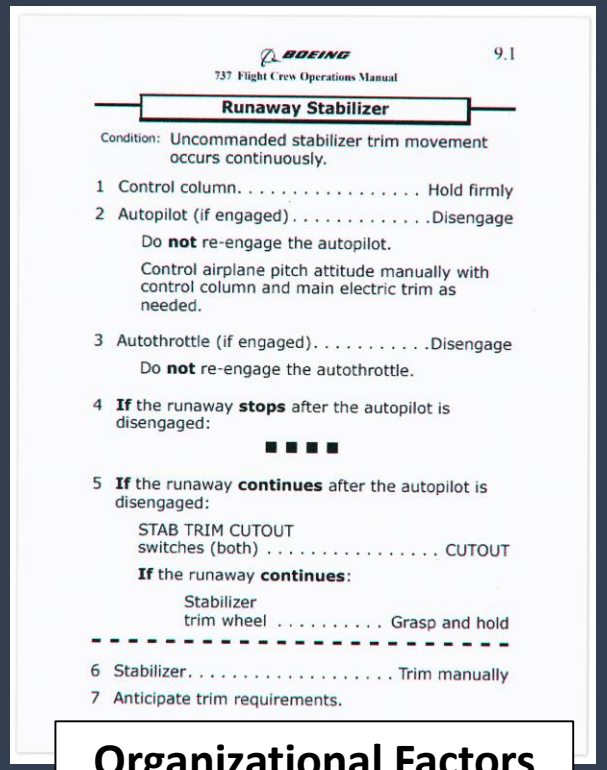
Then (1946-1986)



Still then (1995-2004)



Now (2018-present)



BOEING 9.1

737 Flight Crew Operations Manual

Runaway Stabilizer

Condition: Uncommanded stabilizer trim movement occurs continuously.

1 Control column. . . . . Hold firmly

2 Autopilot (if engaged) . . . . . .Disengage

Do **not** re-engage the autopilot.

Control airplane pitch attitude manually with control column and main electric trim as needed.

3 Autothrottle (if engaged). . . . . .Disengage

Do **not** re-engage the autothrottle.

4 **If** the runaway **stops** after the autopilot is disengaged:

■ ■ ■ ■

5 **If** the runaway **continues** after the autopilot is disengaged:

STAB TRIM CUTOUT switches (both) . . . . . CUTOUT

If the runaway **continues**:

Stabilizer trim wheel . . . . . Grasp and hold

6 Stabilizer. . . . . Trim manually

7 Anticipate trim requirements.

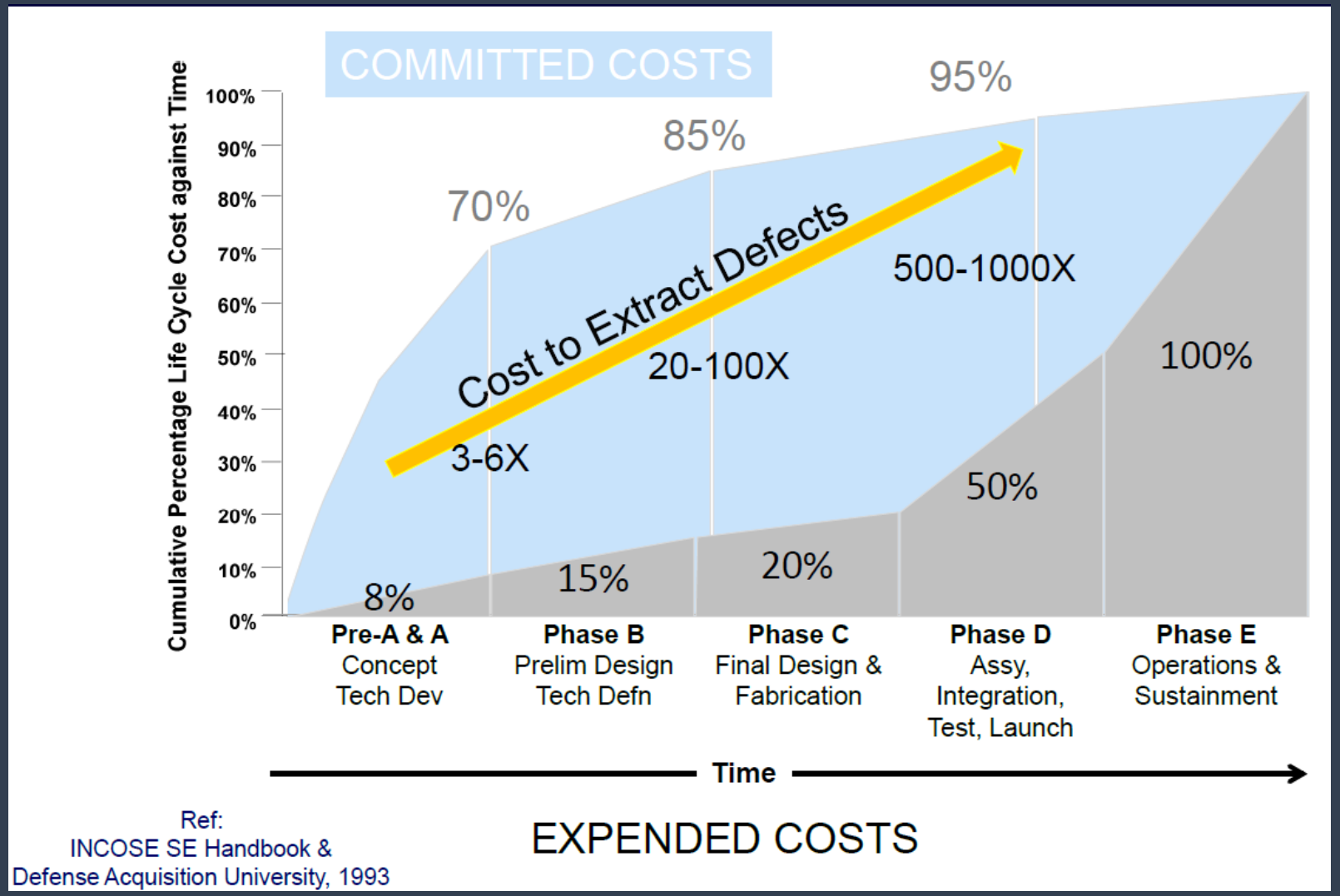
Organizational Factors

Lifecycle Costs

Reduced Manning

See: https://www.theverge.com/2019/5/2/18518176/boeing-737-max-crash-problems-human-error-mcas-faa

When is HSI needed (cont.)?

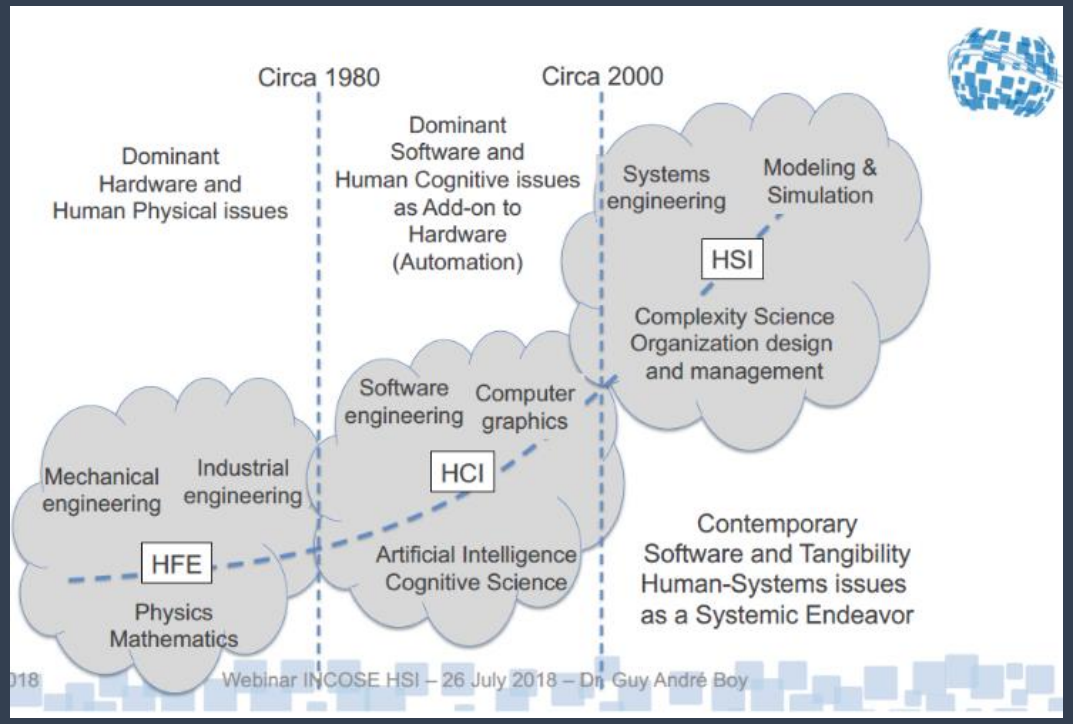


From NASA HSI Practitioner's Guide

https://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/20150022283.pdf

Definitions: INCOSE HSI Working Group

- "The **interdisciplinary technical** and **management** process for integrating human organizational considerations within and across all elements of a socio-technical system during its **whole life cycle** to improve its safety, performance, and comfort."
- … OR
- A specialty engineering discipline
- Something that gets auto-corrected to "HIS".



*Retrieved from: INCOSE HSI webinar (Dr. Guy Boy, 26 July 2018)

https://www.incose.org/incose-member-resources/working-groups/analytic/human-systems-integration

HSI Domains

HUMAN SYSTEMS INTEGRATION DOMAINS

HUMAN FACTORS ENGINEERING

The integration of human characteristics into system definition, design, development, and evaluation to optimize human-system performance under operational conditions.

PERSONNEL

Determining and selecting the appropriate cognitive, physical, and social capabilities required to train, operate, maintain, and sustain systems based on available personnel inventory or assigned to the mission.

HABITABILITY

Establishing and enforcing requirements for individual and unit physical environments, personnel services, and living conditions, to prevent or mitigate risk conditions that adversely impact performance, quality of life and morale, or degrade recruitment or retention.

MANPOWER

Determining the most efficient and cost-effective mix of manpower and contract support necessary to operate, maintain, provide training and support the system.

TRAINING

Developing efficient and cost-effective options that enhance user capabilities and maintain skill proficiencies for individual, collective, and joint training of operators and maintainers.

SAFETY AND OCCUPATIONAL HEALTH

Consider environmental, safety and occupational health in determining system design characteristics to enhance job performance and minimize risks of illness, disability, injury and death to operators and maintainers.

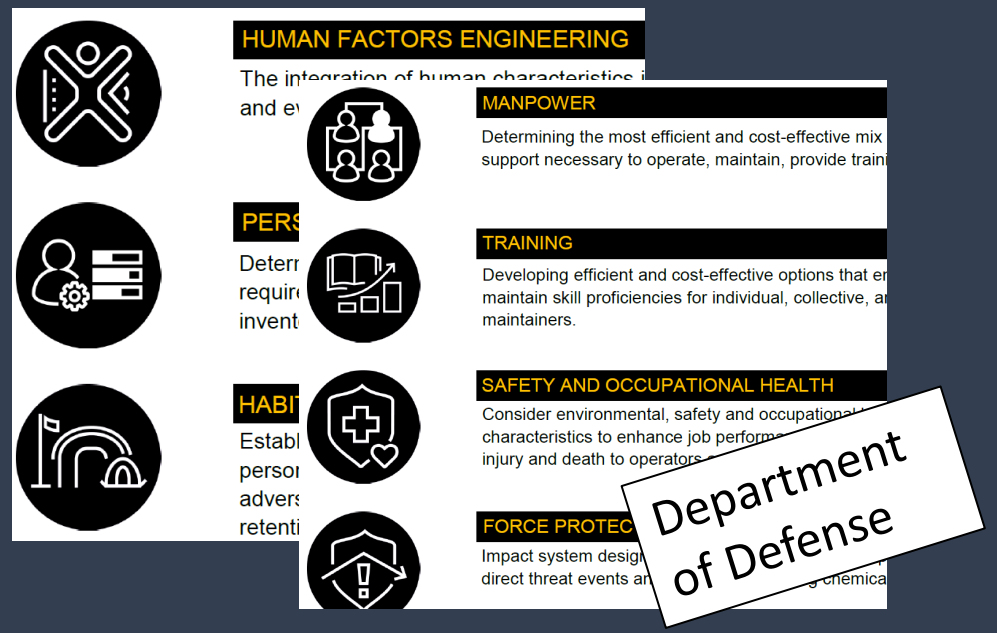
FORCE PROTECTION AND SURVIVABILITY

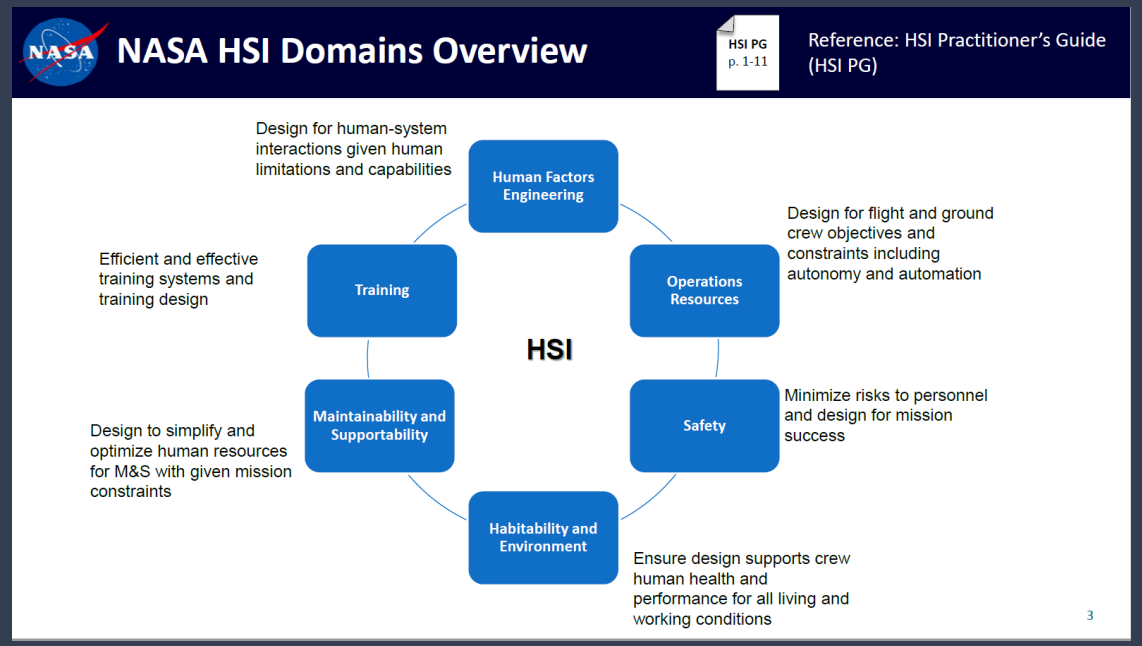
Impact system design (e.g., egress, survivability) to protect individuals and units from direct threat events and accidents, including chemical, biological, and nuclear threats.

Retrieved from:
http://www.armyg1.army.mil/HSI/files/Domains.pdf

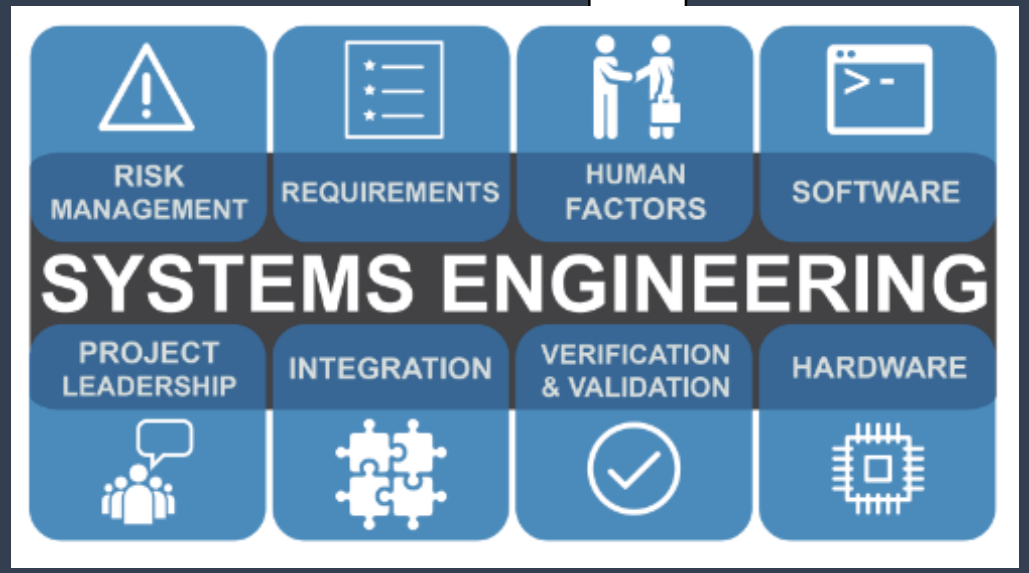
HSI Domains (cont.)

- Every HSI effort requires a blend of these domains (BBQ rub example).
- HSI Domains are evolutionary (e.g. UX)
- Importance is on the <u>tradeoffs</u> between HSI Domains
- Users = Operators, Maintainers, and other Support personnel





Relationship of HSI with Systems Engineering



HUMAN FACTORS ENGINEERING

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Group Checkpoint #1: Impressions of HSI? (~3-5 min)

- Any other terms to include this word map?
- What are your impressions of [insert human-related domain here]? Be honest!

HSI Pitfalls and Mitigations

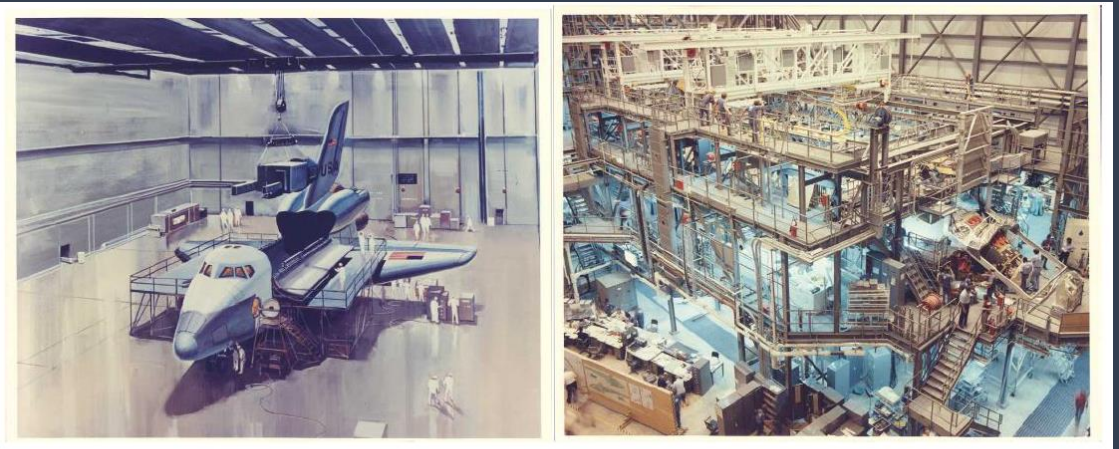
- "HSI is a paper exercise" (In Name Only)
  - Occurs when (often grand) plans in documentation without funding
  - Mitigation: Establish user-centered requirements, timely SOWs
- "I'm not sure what they do" (Unclear)
  - Mitigation: Provide (timely) traceability to systems engineering artifacts
  - Mitigation: Pick up the phone!

- "HSI slows us down / costs too much" (Goldplating)
  - Opportunity cost for critical system development resources: There's no system to integrate if program is "permanently delayed"
  - Short-term thinking tarnishes reputation of the HSI enterprise
  - Mitigation: Be the "honest mechanic", focus on risks and issues

Case Study #1: Shuttle Ground Processing

- Space Shuttle program predicted to conduct 40 round trips per year
- Requires ground processing time of ~5 weeks
- Assumption: Ground processing similar to jet aircraft
- Key Findings
  - Insufficient definition of operational requirements
  - Focus on performance vs. operational considerations
  - Shuttle design organizations not responsible for operational cost
- Result
  - Labor intensive (high operational cost) vehicle was developed and put into operations
- Key Lessons Learned
  - Must have continuity and integration between designers, ground operations, and flight operations requirements during the development phase.

Conceptual | **Actual**



Source: Bo Bejmuk, Space Shuttle Integration (Lessons Learned Presentation)

From NASA HSI Practitioner's Guide
https://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/20150022283.pdf

Case Study #2: F-119 Engine

- Prototype to the F22
- USAF added requirements for reliability, maintainability, and supportability (RM&S)
- Key findings
  - Conducted 200+ trade studies, emphasizing HSI evaluation criteria (e.g., safety, training)
  - Conducted interviews w/ maintainers
  - Established Integrated Product Development (IPD) teams
- Result
  - Maintainable with 5 hand tools
  - Line replaceable units that are “one-deep”, removable w/in 20 minutes (w/ PPE)
- Lessons Learned
  - Document desired outcome via formal HSI deliverables, requirements
  - IPDs now common SE practice (as IPTs)

Figure C.3-1 F-119 Engine Cutaway (Pratt and Whitney, 2002)

From NASA HSI Practitioner’s Guide
https://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/20150022283.pdf

Case Study #3: F-22 Hypoxia

- Reductions in Force severely limited HSI funding throughout development
- Backup Oxygen System removed to save weight
- Key Findings
  - Relied on emergency system
  - Oxygen saturation requirement reduced from 99%+ to 93-94%
  - Limited understanding of operational environment (i.e., 50,000 ft)
- Result: Pilots experienced hypoxia, respiratory systems after flight
- Lesson Learned
  - HSI should be conducted throughout the whole system lifecycle

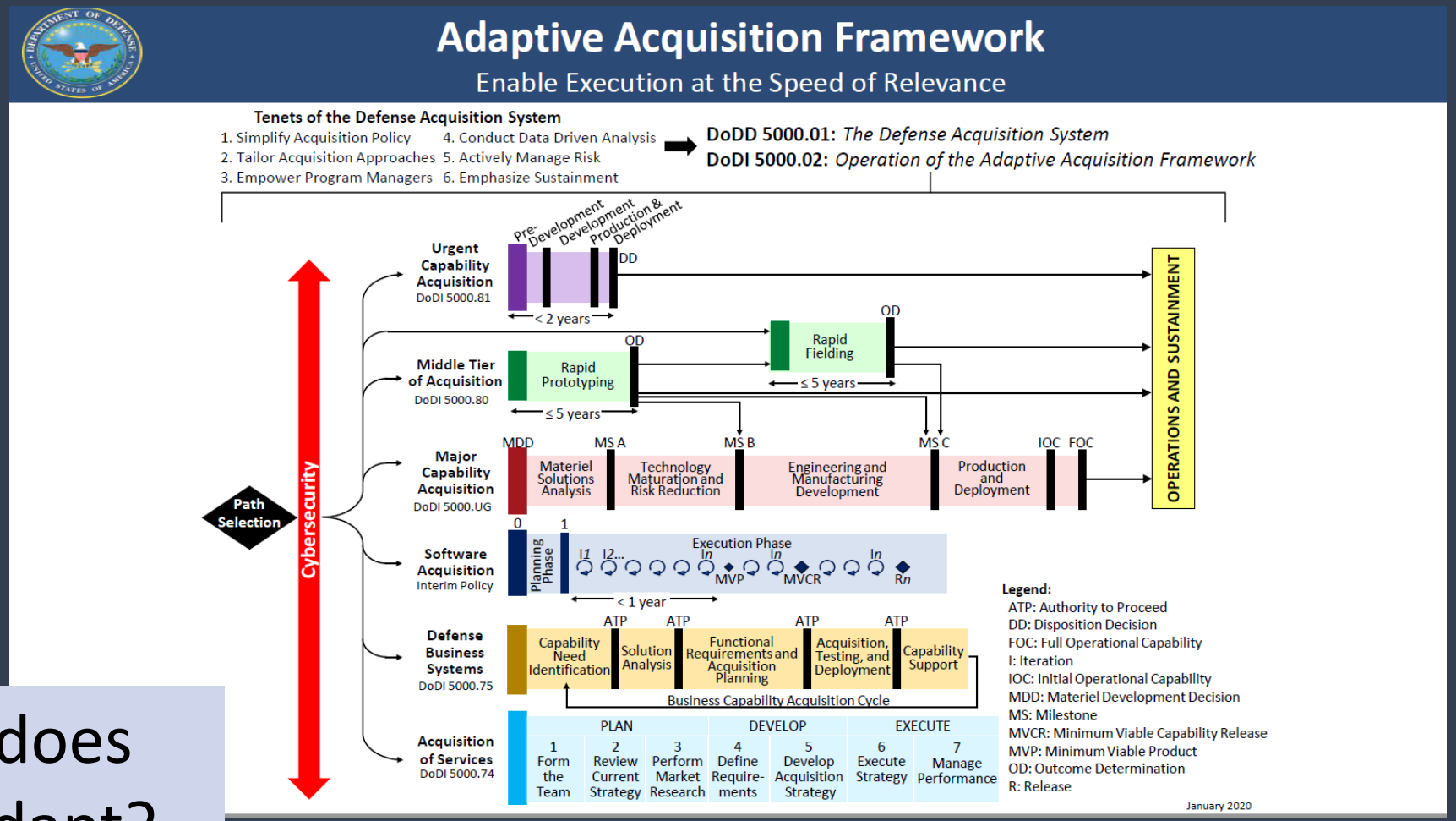
From NASA HSI Practitioner's Guide
https://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/20150022283.pdf

HSI Trend: Adaptive Acquisition Framework

- THEN: Focus on fielding **systems**
  - Hardware-intensive: Major weapons platforms
  - Follows traditional, V-Model of systems engineering
  - Software components utilize Waterfall methodologies
- Useful for fielding systems with stable capabilities and long life cycles
  - F-16 (1974 ->)
  - USS Nimitz (1975 ->)
  - Individual Master File (1960s ->)

- NOW: Focus on fielding **capabilities**
  - Mix of software and hardware, System of Systems approaches
  - Software components utilize Agile Development and DevOps concepts
  - Short life cycles (Windows XP = 7 years, iOS 1.0-12.0 = 10 years)
- Challenges
  - **Managing Risk:** More expensive, less time to "figure it out"
  - **Managing Complexity**: Sub-systems as machines vs. natural systems
  - **Ensuring Rigor:** Document vs. Model-Based Systems Engineering
- Opportunities
  - **Flexibility:** Agile SE, Agile Software Dev allows for course correction
  - **User feedback:** Feedback (good and bad) travels fast!

HSI Trend: Adaptive Acquisition Framework (cont.)



How does HSI adapt?

From DAU presentation by M. Coolican, see https://aaf.dau.edu/

Checkpoint #2: Project Experiences

- Roundtable discussion on HSI-like experiences in your own projects
  - How was HSI conducted? Were they even called as such?
  - What pitfalls (or best practices) did the HSI practitioners experience?
- What kind of methods in your own technical toolset can be used to help these user-related efforts?

Take-aways

- “I’m not a HSI practitioner, but this was interesting. How I do get involved?”
  - Reach out to “human types” in your organization (we tend to be lone wolves / small packs)
  - Think about the “human perspective” in your work
  - Keep learning!
- Feedback / Questions: frank.c.lacson@outlook.com