
Exploration Systems Mission Directorate
Exploration "System of Systems"
Spiral Development
Discussion Panel #2
Moderator: Jim Nehman
Deputy AA, Development Programs
February 1, 2005

"System of Systems" – Spiral Development

- **Moderator: Jim Nehman**
  - NASA ESMD Deputy AA, Development Programs

- **Panelists:**
  - Mr. Garry Lyles
    - NASA ESMD Director, Constellation Systems
  - Mr. John Mankins
    - NASA ESMD Director, Exploration Systems Research & Technology
  - Admiral Steve Enewold, USN
    - PEO / Director, Joint Strike Fighter Program
  - Mr. John Douglass
    - President / CEO Aerospace Industries Association

Vision Requires System-of-Systems Integration

Cross-Agency Coordination & Integration

Transit and Launch Systems

Crew Transport

Launch

Crew Support

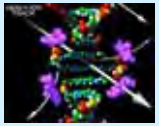
The Human: an Essential Element of the System of Systems

Surface and Orbital Systems

Landing Systems

Comm/Nav

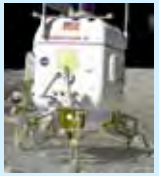
Surface Mobility



Biomedical Countermeasures and Limits

Resource Identification and Characterization

Supporting Research



Long-Duration Habitation

Pre-Positioned Propellants

Surface Power and Resource Utilization

Technology Options

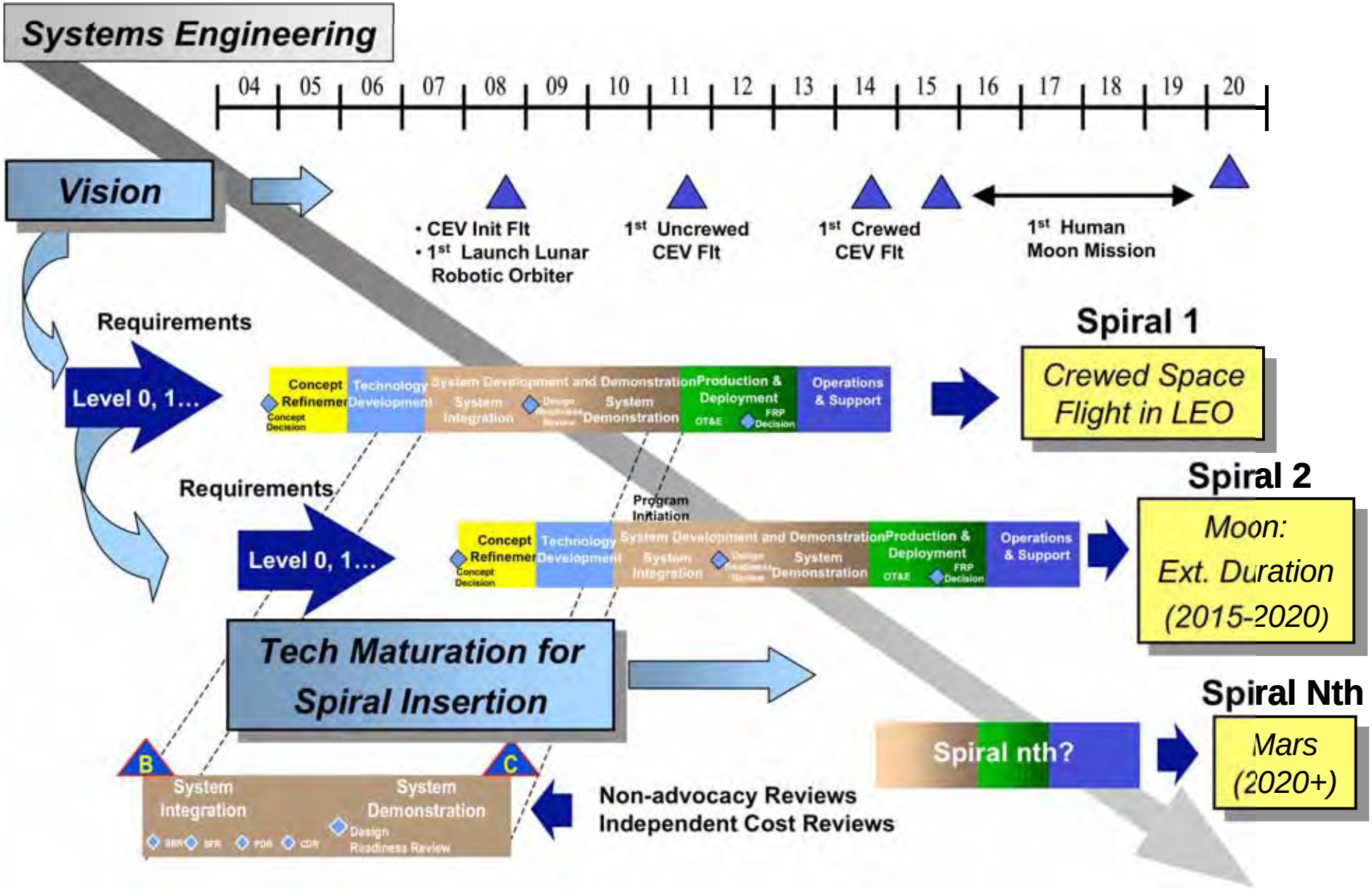
Mars Candidates

Telescope Candidates

Outer Moons Candidates

Commonality/Evolvability For Future Missions

Project Constellation – Spiral Development



Constellation Systems - Approach to Spiral Development

Garry Lyles

Director, Constellation Systems

1st Space Exploration Conference

1 February 2005

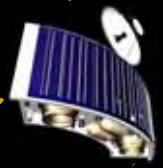
Constellation System of Systems

Crew Transport, Launch Systems & Ground Systems

And Beyond

In-Space Support Systems

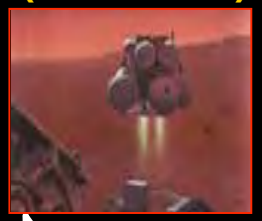
(e.g. Communication System, EVA systems)



Earth

Planetary Access

(moon & Mars)



Space Transportation Systems

(moon & Mars)

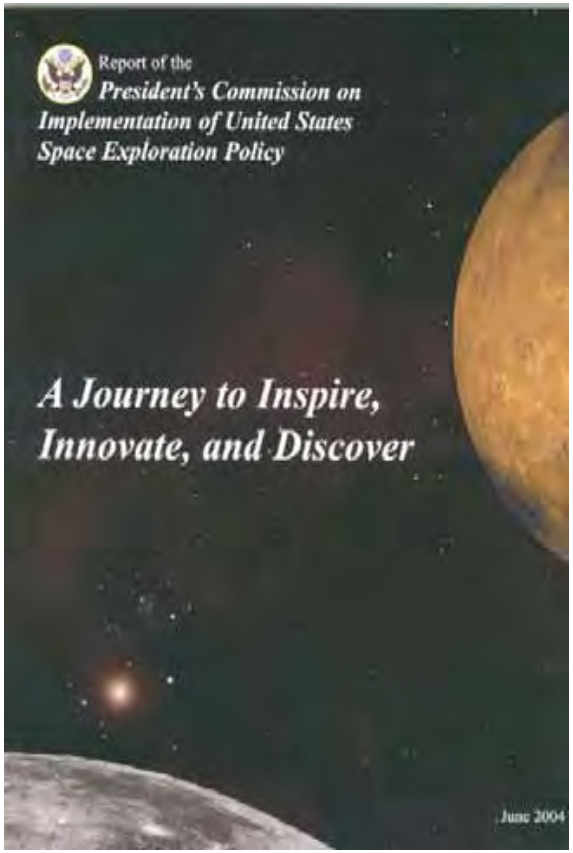
Mars

Moon

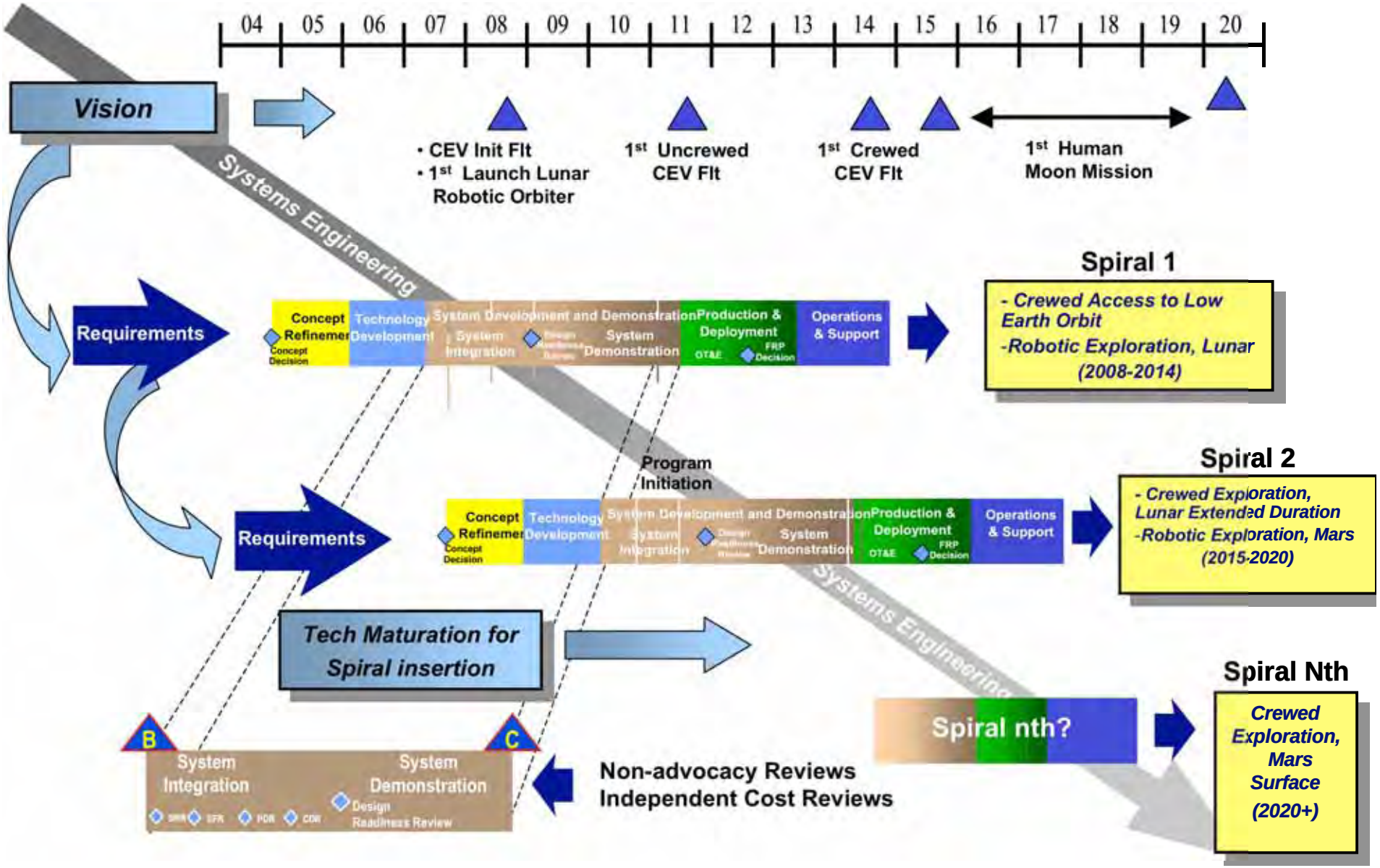
Destination Surface Systems

- **Use of "system of systems" approach;**
  - *"Implementation of the exploration vision entails stitching together thousands of discrete components and interdependent tasks into a single 'system-of-systems'."*

- **Policies of spiral, evolutionary development;**
  - *"The key to this concept is to establish realistic, integrated technology development plans that will achieve early performance capabilities and allow new technologies to be 'spun' into the program when they are mature enough to do so - thus improving performance and capability in cycles."*

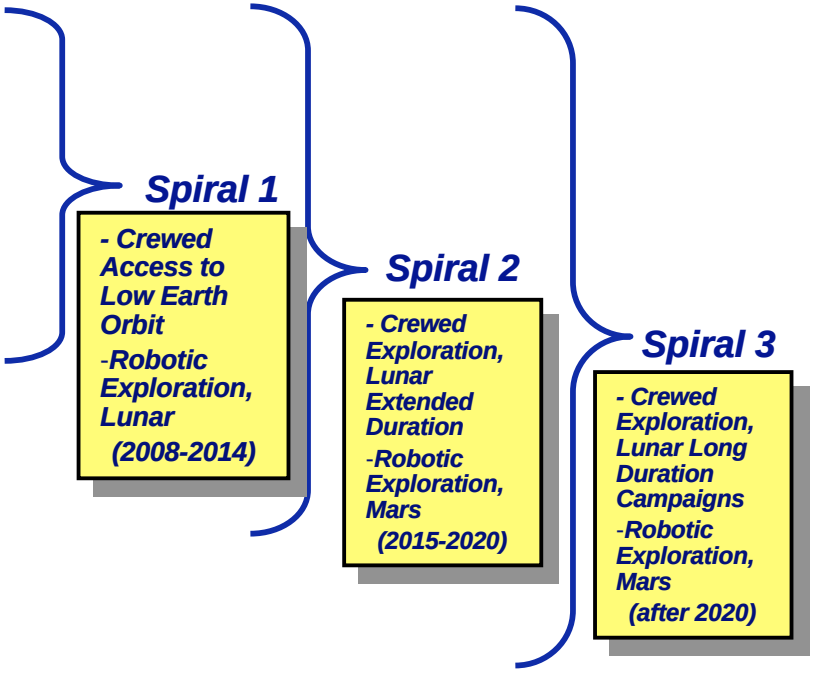


Constellation Systems
Spiral Acquisition Process

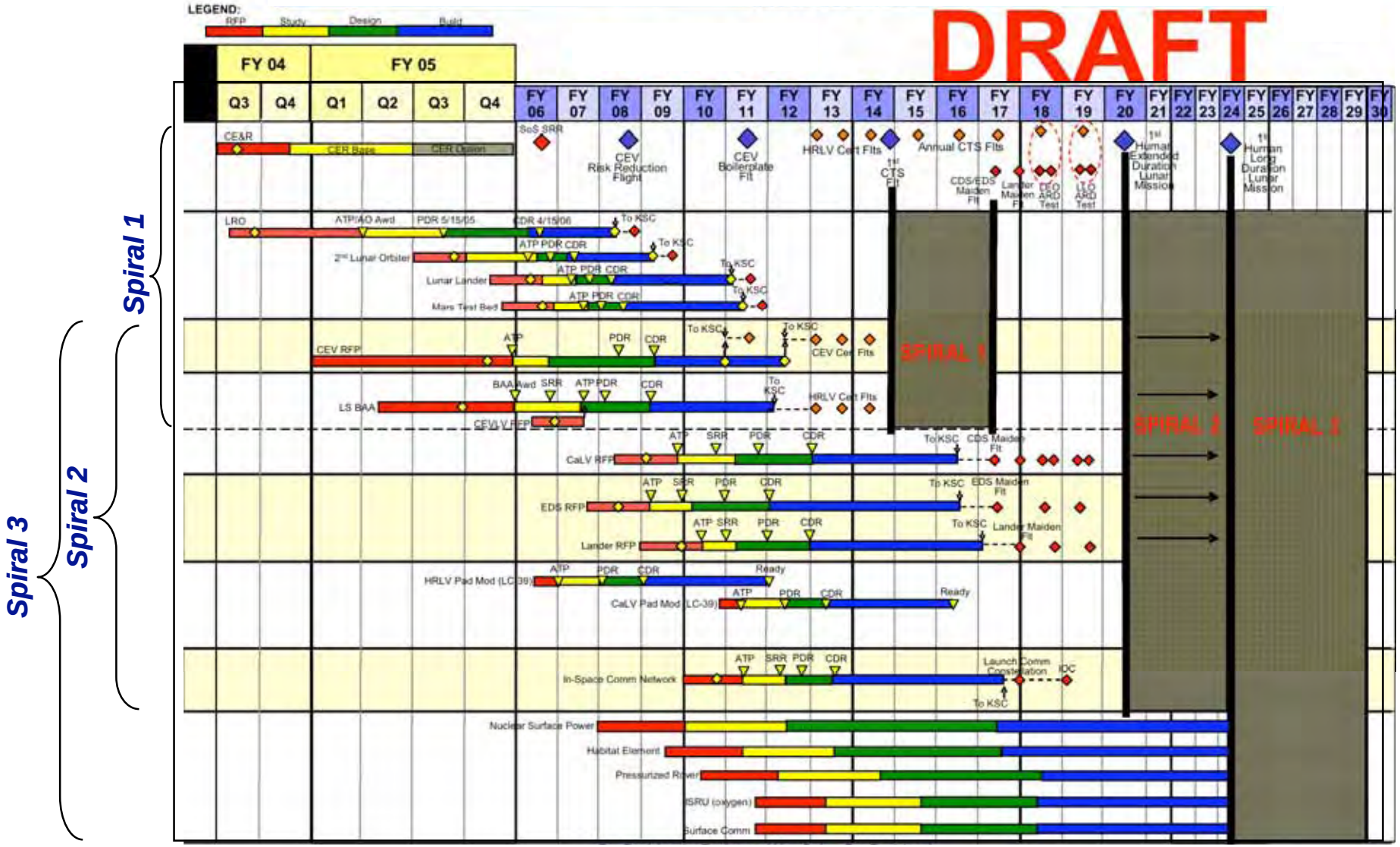


Constellation Definition

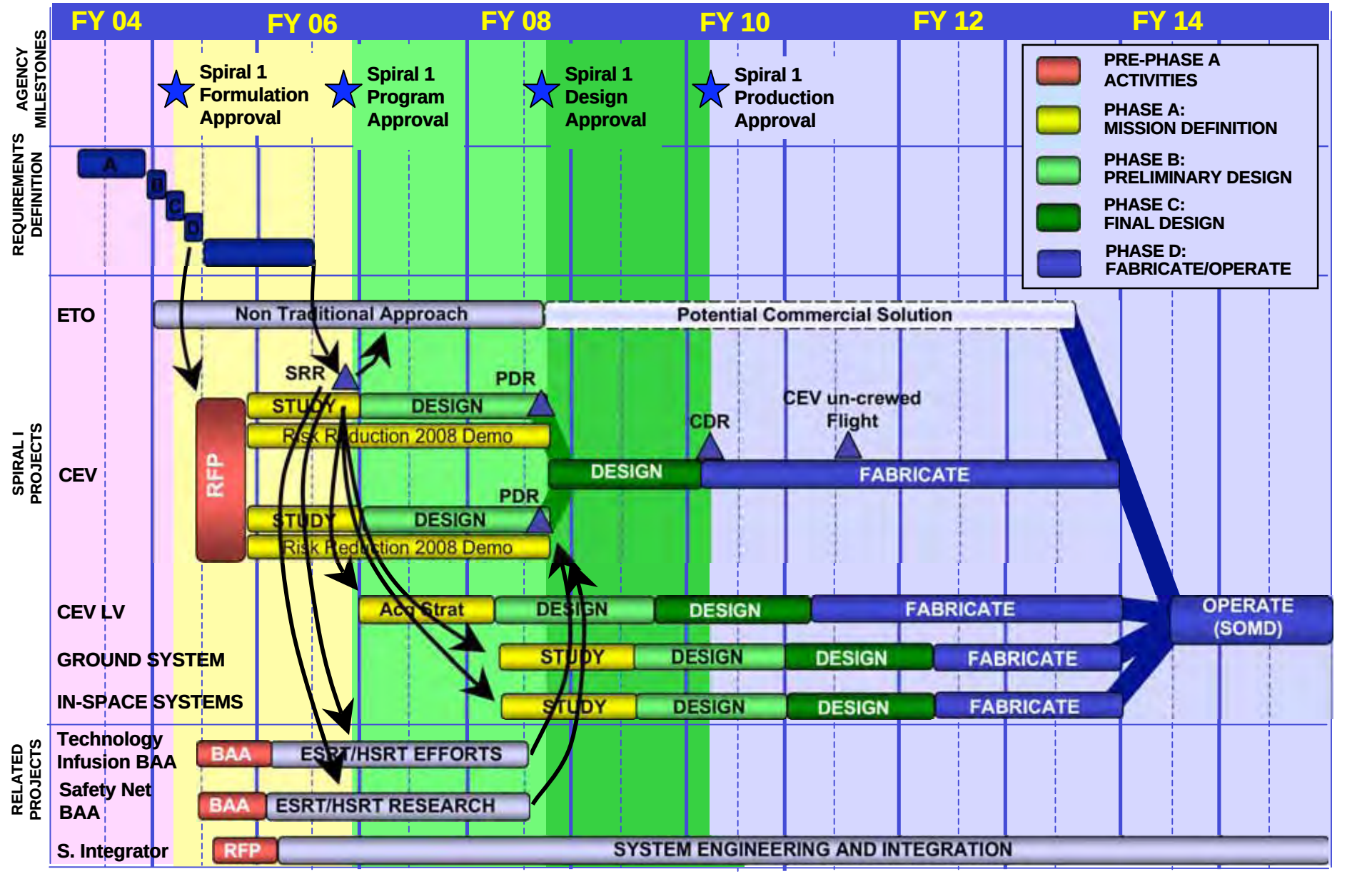
- **Develop, demonstrate, and deploy successive generations of capabilities to enable the sustained human and robotic exploration of the Moon, Mars, and beyond.**
- **Developed capability will form a system-of-systems that includes:**
  - Crew Transportation Systems
    - *Crew Exploration Vehicle (CEV)*
    - *Crew Launch Vehicle (CLV)*
  - *Ground Support Systems (GSS)*
  - In-Space Support Systems (ISSS)
  - Space Transportation Systems
  - Human System Support
  - Destination Surface Systems



Example Integrated Constellation Acquisition Schedule
Spirals 1, 2, 3



Spiral I Program

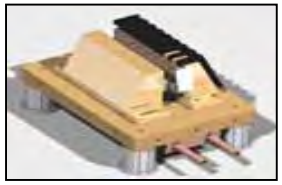


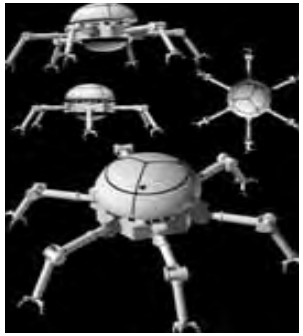
Summary - One Step at a Time

- **Spiral development enables affordable, sustainable solutions**
  - Focused on successive steps toward a system of systems
  - Paced by experience, technology readiness and flexibility
  - Driven by requirements
  - Responsive to innovative acquisition strategies


Exploration Systems Mission Directorate
Exploration Systems Research and Technology
OVERVIEW
John C. Mankins
Manager, Exploration Systems Research & Technology
February 1, 2005

Exploration Systems Research & Technology





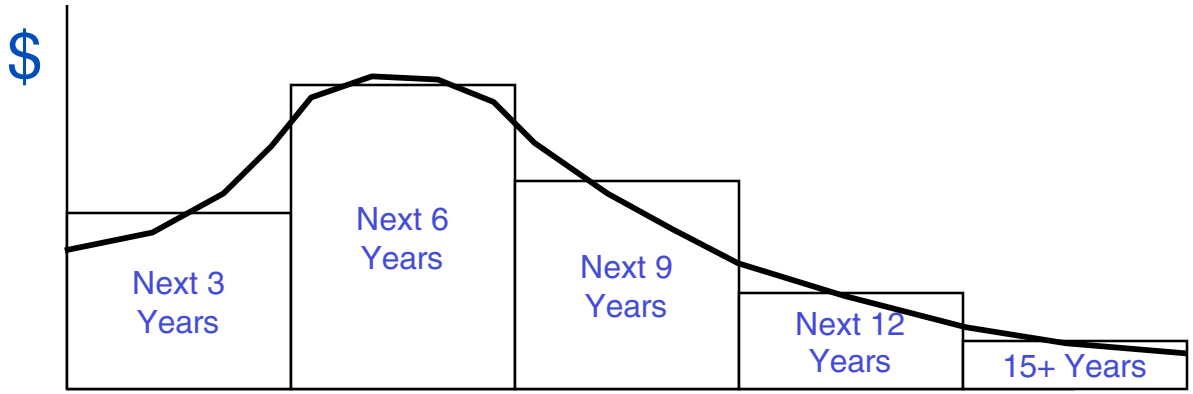
ESR&T **is a strategic, requirements-driven investment that** enables future exploration systems and missions that are more affordable, reliable, effective and flexible

ESR&T investments range from lower technology readiness level (TRL) R&D projects for the mid- to far- term through the Advanced Space Technology Program**, to higher TRL projects for the near- to mid-term through the** Technology Maturation Program**, as well as cross-cutting efforts to engage universities, small business and the entrepreneurial community through the** Innovative Partnerships Program

ESR&T projects support future ESMD 'system development spirals' by delivering timely data to inform systems decisions **based on R&D results and validated, high-leverage** new technologies incorporated into future system developments

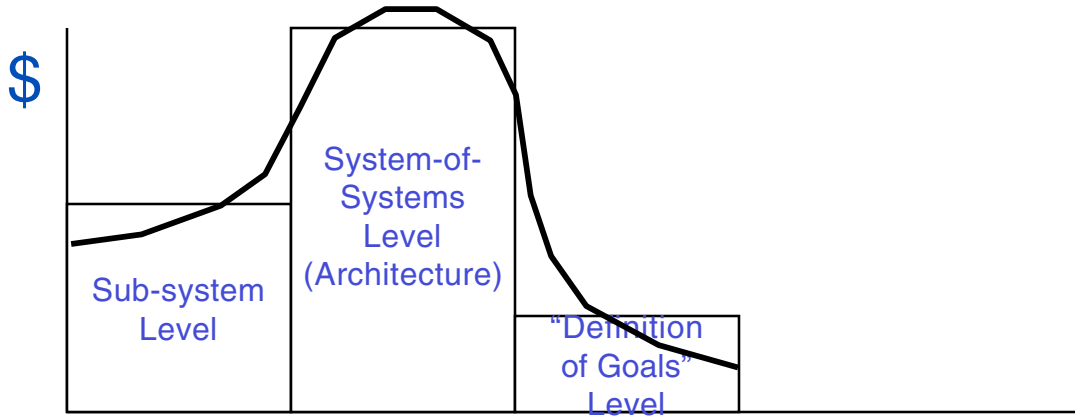
Exploration Systems Research & Technology
Investment "Balance" - 2 Views

H&RT Strategic Focus: TIMEFRAME
(By which Technology Must be Proven)



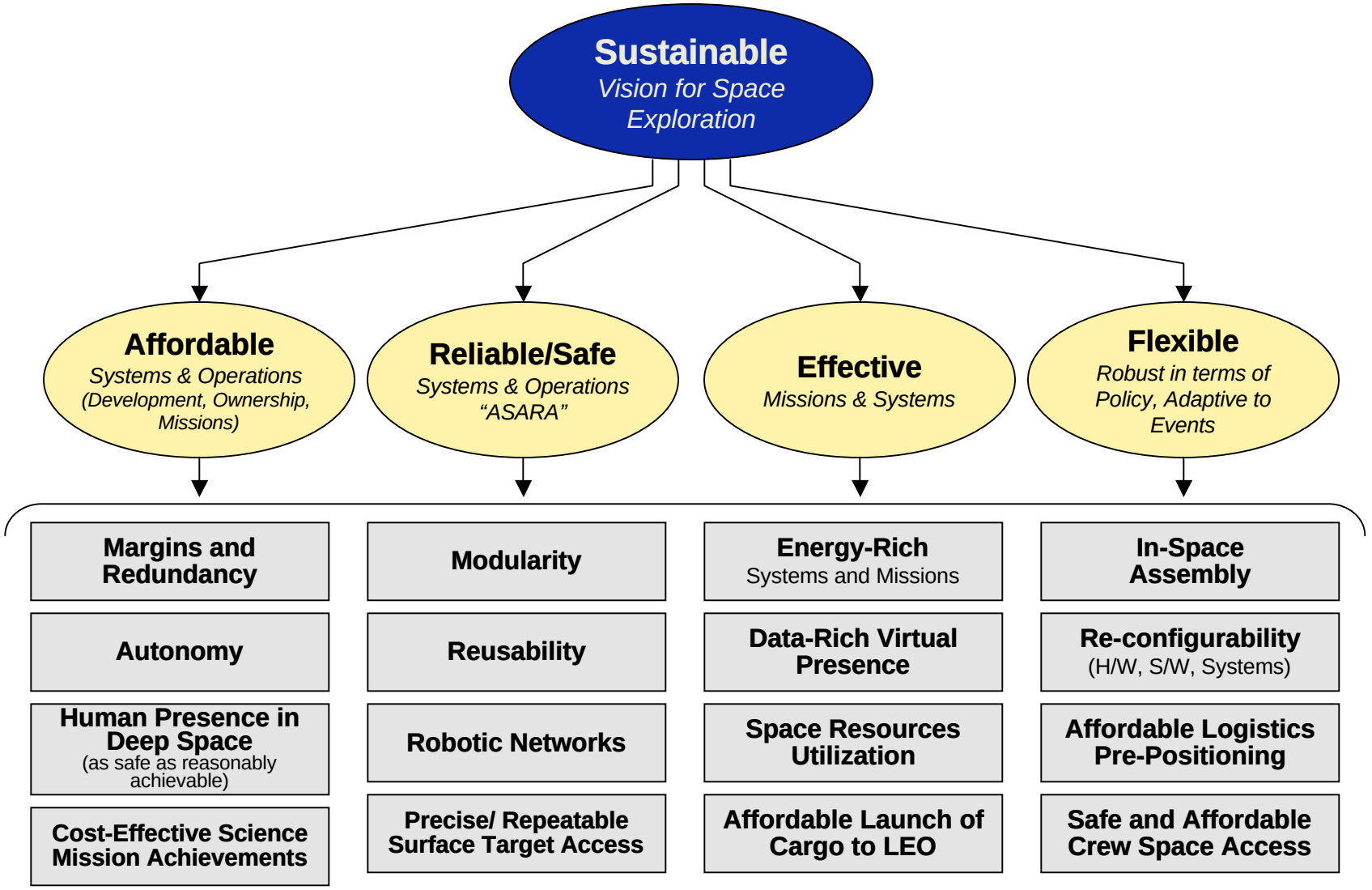
Timeframe
(When Maturity Must be "Proven")

H&RT Strategic Focus: IMPACT
(of the Technology Expected to be Seen in Missions/Systems)

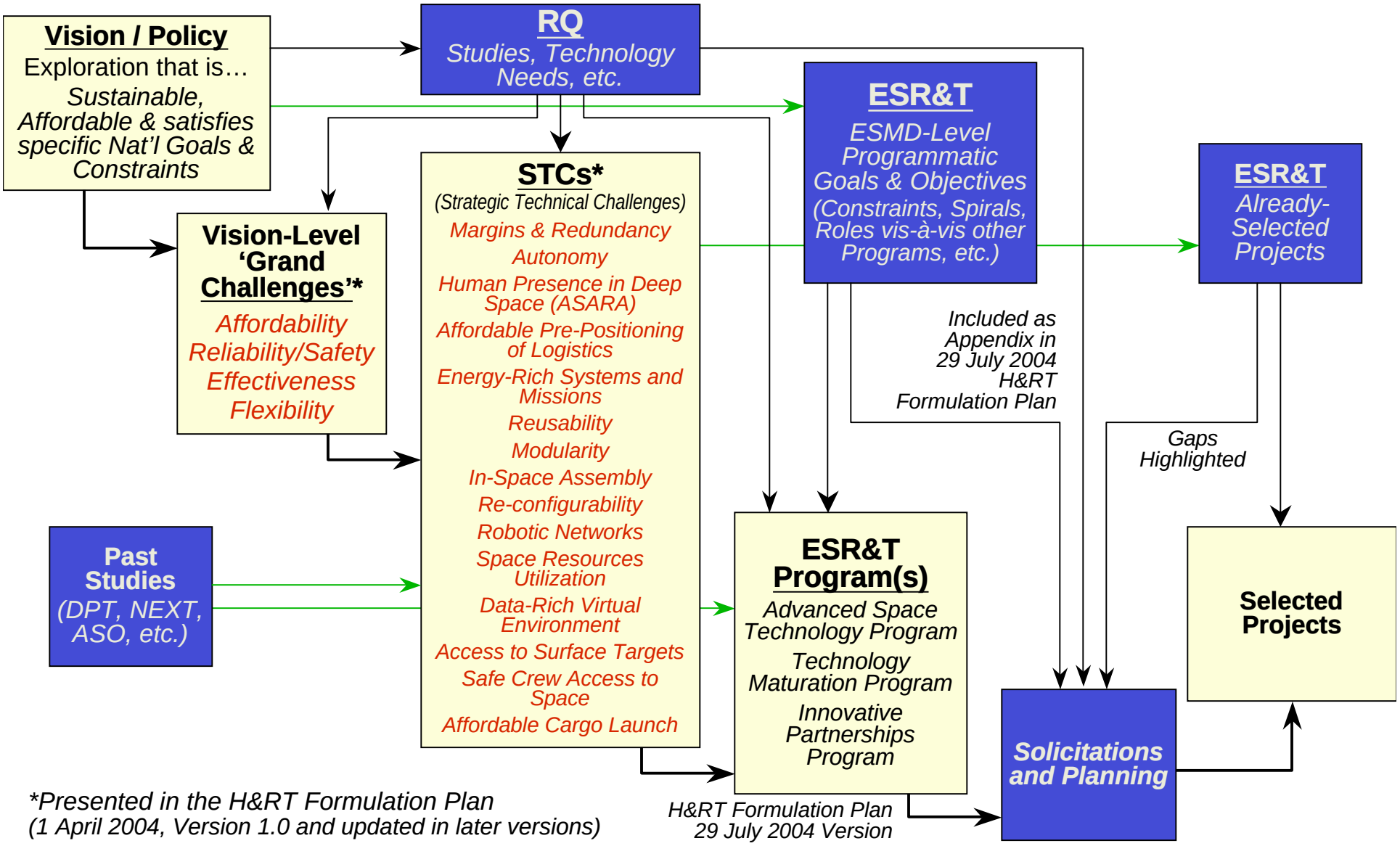


Scale of Impact
(What Influence Will the Technology Have, if "Proven")

Exploration Systems Research & Technology
Strategic Technical Challenges



Exploration Systems Research & Technology
Traceability



*Presented in the H&RT Formulation Plan
(1 April 2004, Version 1.0 and updated in later versions)

ESR&T Coverage
ESMD RQ Identified Technology Needs

	ASTP					TMP					IPP
	Advanced Studies, Concepts And Tools Program*	Advanced Materials and Structural Concepts Program	Communications, Computing, Electronics & Imaging Program	Software, Intelligent Systems & Modeling Program	Power, Propulsion & Chemical Systems Program	High Energy Systems Technology Program	Space Platforms and Systems Technology Program	Space Operations Technology Program	Lunar and Planetary Surface Operations Technology Program	In-Space Technology Experiments Program	IPP Summary (SBIR, STTR, TTA, URETIs, RPC's)
Requirement Division Identified Technologies											
Human Support											
Radiation Protection	✓	✓	✓						✓	✓	✓
Medical Care	✓									✓	✓
Life Support System Closure	✓									✓	✓
Human -System Design	✓		✓	✓						✓	✓
In-Space Transportation											
Advanced Chemical Propulsion	✓				✓	✓				✓	✓
Electric Propulsion	✓				✓					✓	✓
Nuclear Thermal Propulsion	✓									✓	✓
Cryogenic Fluid Management	✓	✓			✓	✓				✓	✓
Aeroassist	✓	✓			✓	✓				✓	✓
Automated Rendezvous and Docking	✓	✓	✓				✓	✓		✓	✓
Power											
Power Generation (Solar)	✓				✓	✓				✓	✓
Power Generation (Nuclear)	✓									✓	✓
Mobile Power (Advanced Batteries)	✓				✓				✓	✓	✓
Mobile Power (Fuel Cells)	✓				✓				✓	✓	✓
Mobile Power (Radioisotopes)	✓									✓	✓
Energy Storage	✓				✓					✓	✓
Power Distribution	✓			✓	✓	✓	✓			✓	✓
Miscellaneous and Crosscutting Technologies											
Sensors and Instruments	✓	✓	✓							✓	✓
In-Situ Resource Utilization	✓	✓	✓		✓				✓	✓	✓
Advanced Materials	✓	✓								✓	✓
Thermal Management	✓	✓			✓	✓				✓	✓
Advanced Habitation	✓	✓					✓			✓	✓
Advanced EVA	✓	✓	✓	✓				✓		✓	✓
Robotic Human Support	✓		✓	✓				✓	✓	✓	✓
On-Board Computing	✓		✓				✓	✓		✓	✓
Simulation-based Design and Analysis	✓		✓	✓				✓		✓	✓
Communications	✓		✓				✓			✓	✓
Supportability	✓		✓				✓	✓	✓	✓	✓

JOINT STRIKE FIGHTER
the next generation strike fighter

JOINT STRIKE FIGHTER PROGRAM BRIEF

1 February 2005

Rear Admiral Steven L. Enewold, USN
Program Executive Officer, Joint Strike Fighter Program

VISION

DELIVER AND SUSTAIN
THE MOST ADVANCED, AFFORDABLE
STRIKE FIGHTER AIRCRAFT
TO PROTECT
FUTURE GENERATIONS WORLDWIDE.

What Is JSF?

The next generation “family” of strike fighters

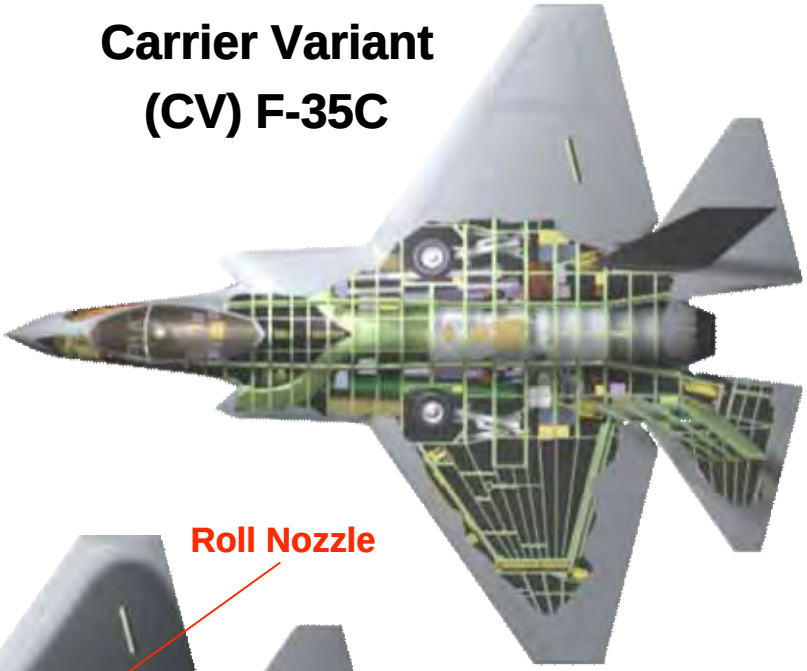
- F-16/F/A-18C “like” aero performance
- Stealth Signature and Countermeasures
- Advanced avionics, data links and adverse weather precision targeting
- Increased range with internal fuel and weapons
- Highly supportable, state of the art prognostics and health management

Lethal Survivable Supportable Affordable

JSF Family Of Aircraft (F-35 A/B/C)

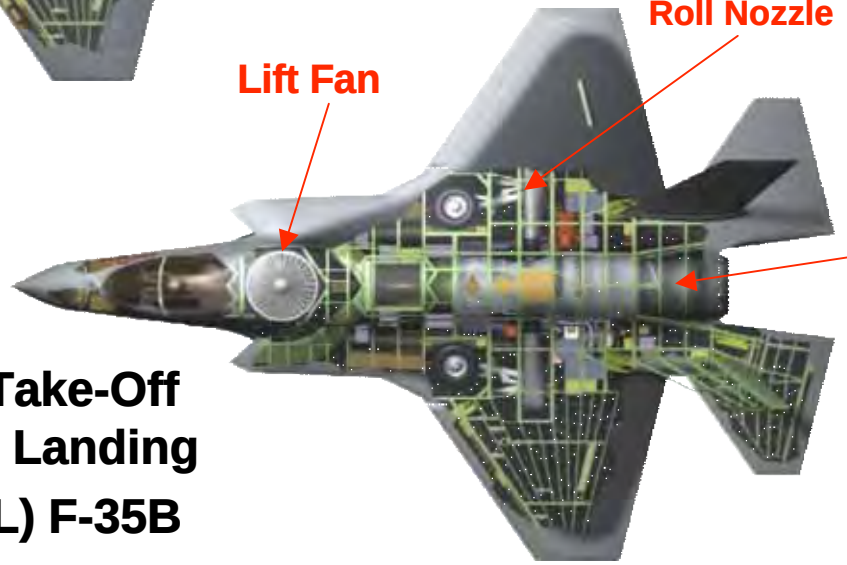
Conventional Take-Off and Landing (CTOL) F-35A

Carrier Variant (CV) F-35C



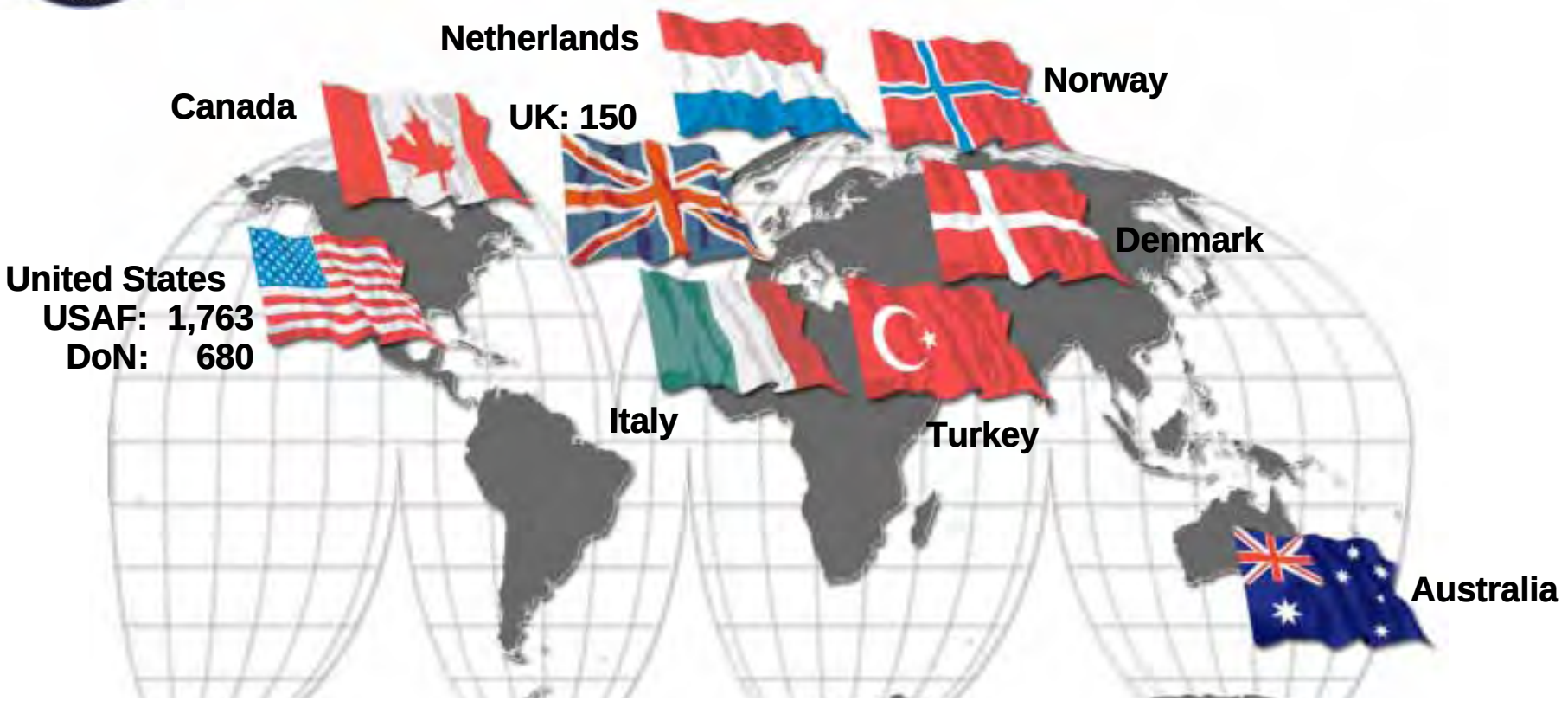
All variants

- •450-600 nm Range
- •1.6 Max Mach (Limit)
- •Stealthy
- •Same Weapons
- •Similar Avionics
- •Similar Flight Envelope
- •Same Basic Engines



Short Take-Off Vertical Landing (STOVL) F-35B

Service & International Needs

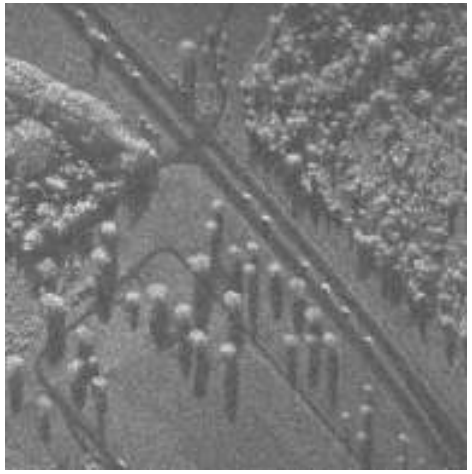


- **USAF:** Multi-role (primary air-to-ground) fighter to replace F-16 & A-10 & to complement F/A-22
- **USMC:** Multi-role, short takeoff, vertical landing strike fighter to replace AV-8B & F/A-18C/D
- **USN:** Multi-role strike fighter to complement the F/A-18E/F
- **UK (RN and RAF):** Supersonic replacement for Sea Harrier and GR-7

2,593 US/UK JSFs > 2,000 International JSFs

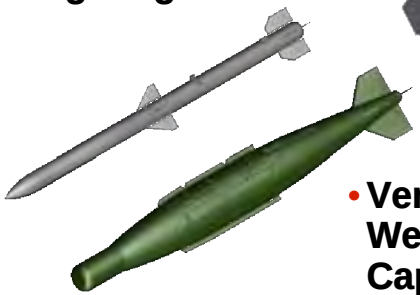
JSF Warfighter Capability Highlights

- Cooperative Ops
- Full Off-Board Connectivity



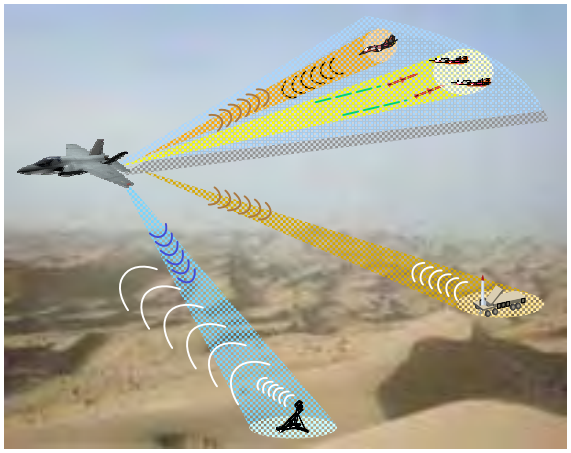
- Multi-Function AESA

- EO Targeting



- Versatile Weapons Capability

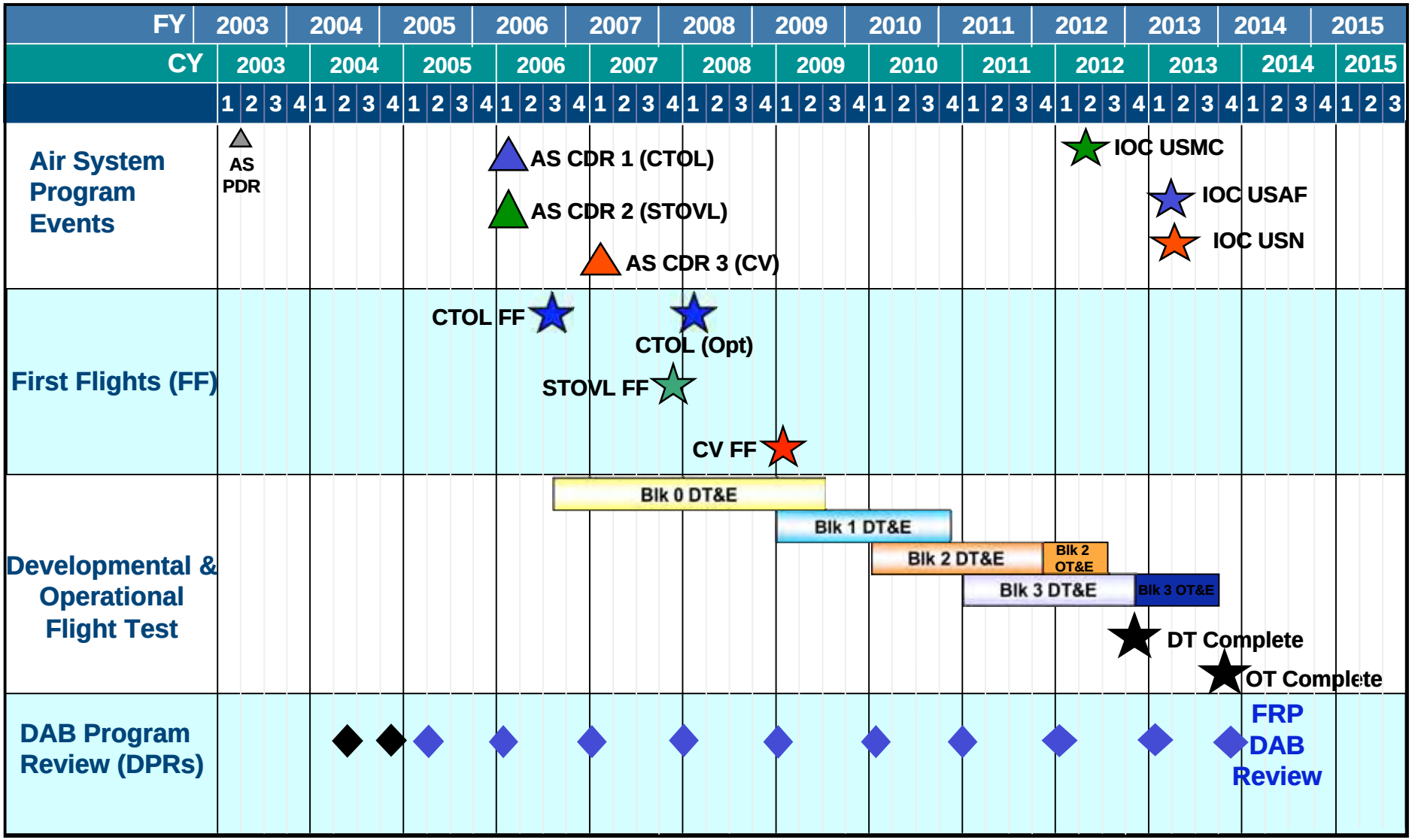
- All Around Situation Awareness



- Passive Precision Emitter Location and Targeting

- Fused, Coherent Common Operational Picture

JSF Top-Level SDD Program Schedule



JSF Spiral Development Strategy

Block 0.1 – Support First Flight / Flight Test Objectives
Basic functions to Get the Aircraft Flying

= "Block 0"

Block 0.5 – Initial MS Architecture & Sensor Infrastructure
Mission systems infrastructure Build supporting sensor and architecture development

Block 1 – Initial Warfighting Capability
Flight qualified, baseline air-to-air and air-to-ground weapons qualified. Pilot and maintenance training can commence.

Block 2 – Close Air Support and Interdiction
Qualifies additional air-to-air and air-to-ground weapons. Services can start planning deployments and staffing operational units.

Block 3 – Suppression of Enemy Air Defenses ***Qualifies additional a/a & a/g weapons for use. Service Initial Operational Capabilities are achievable.***

Supports 7 Flight Performance Aircraft

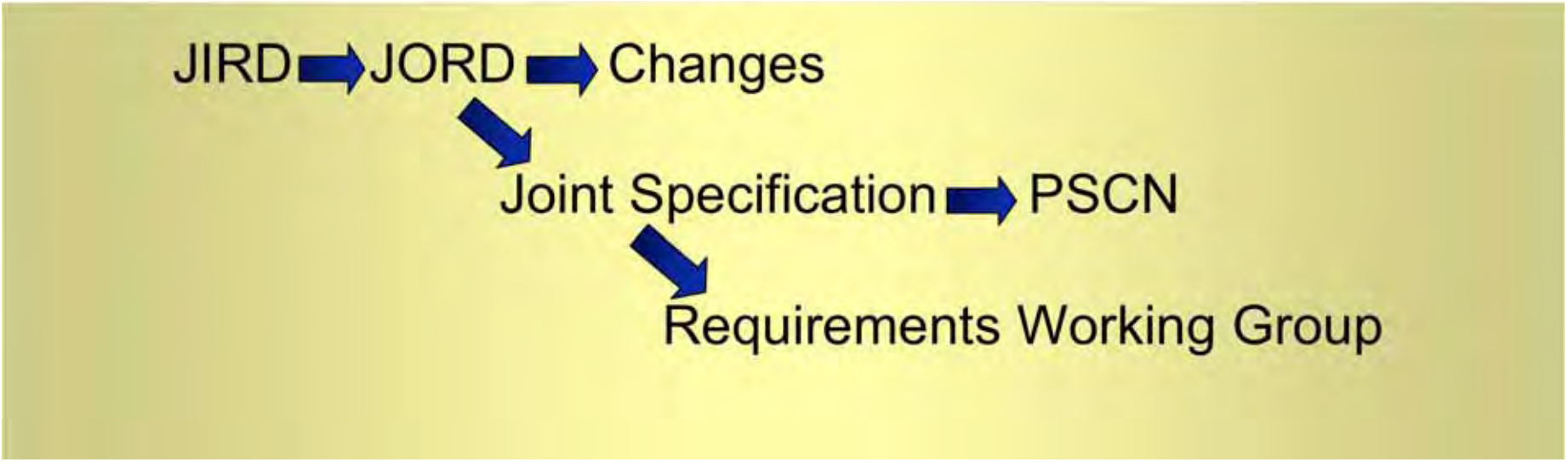
Initial MS Tactical Sensors Integration "Avionics FF(A3)" Initial Weapons Testing

Bulk of MS Hardware on Board

Primarily Software Updates with Added Weapons

Spiral Development Process

Requirements Management



GOODS

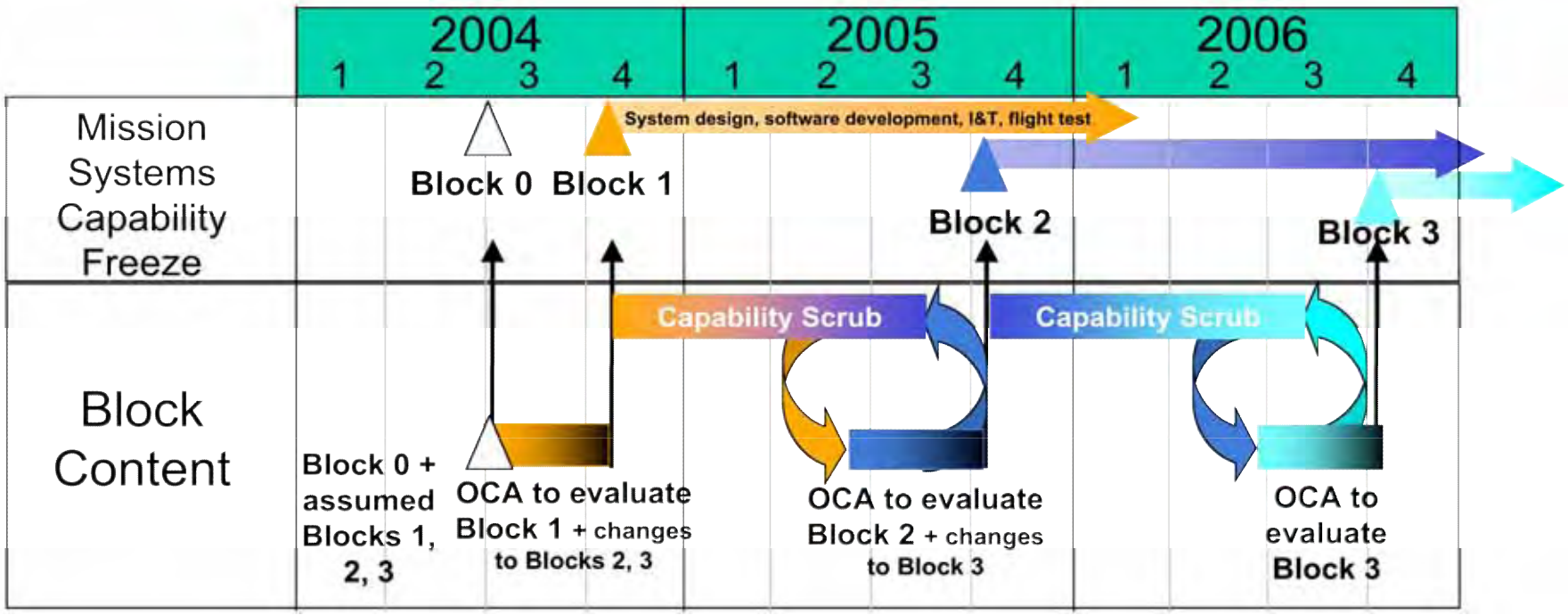
- **Documented Rationale**
- **Decision Delegation**
- **Operational Advisory Group**
- **Joint Requirements Review Team**
- **Configuration Management**

OTHER

- **Overused Term**
- **Cost As Independent Variable**
- **“Pet Rocks” and Priorities**
- **Slow Process**

Block Plan Spiral Approach

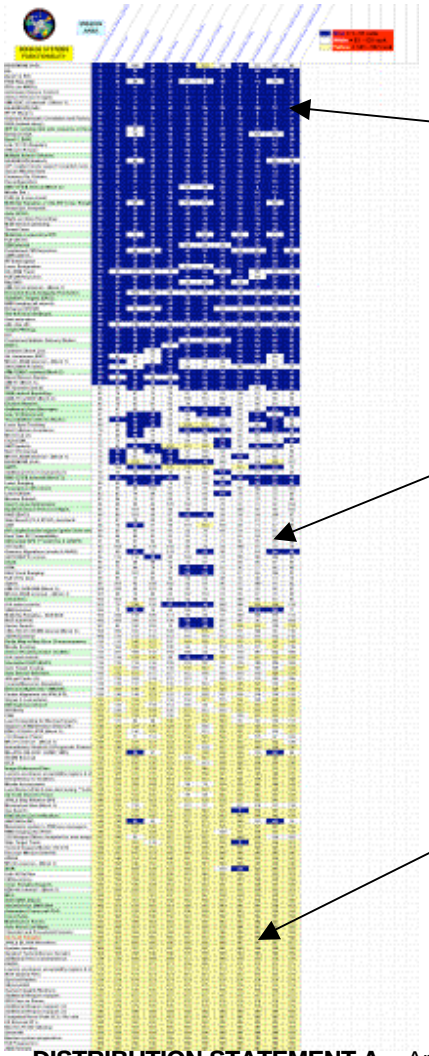
- **Phase approach to Block development and Capability Freeze**
  - — Operational Capability Assessments refine block requirements through ops analysis and using warfighter input
  - — Current program execution defines development capacity for each upcoming block
  - — Incremental Capability Releases towards end of block development take advantage of proven (stable, verified, certified) capabilities to support stakeholder needs
- **Capability Freeze Defines Block Scope Prior To Start Of Block Lifecycle**



OAG Mission - Capabilities Rank Order Consensus

OAG Missions

Columns Sorted by OAG Mission Importance

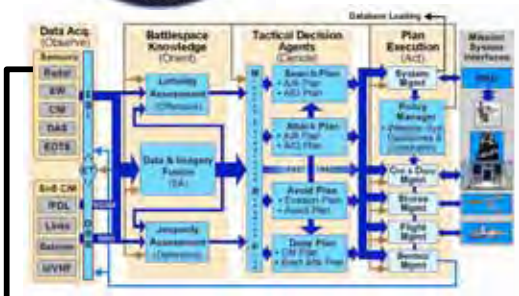


Blue Background = In the OAG's top third for that mission column

White Background= In the OAG's middle third for that mission column

Yellow Background = In the OAG's bottom third for that mission column

Block Based Annex C Scenario Utility Relationships



ORD Annex C Block 1 Scenario

ORD Annex C Block 2 Scenario

ORD Annex C Block 3 Scenario

Radar Subsystem

Block 0.2/0.3

Block 1

Block 2

3

Capability Reinforcement Feed-Back Lanes

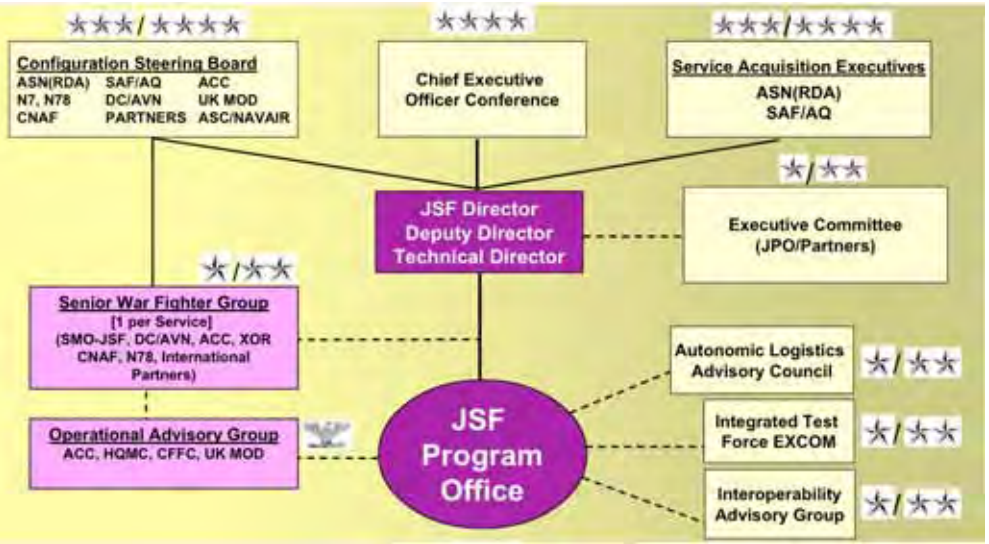
Block 1 Capabilities that contribute to Annex C Blk 2 & 3 Needs {Early Cap for Blk 1 birds}

Data Acq Function & Ownship Sensor Architecture Domain

Radar Functional Capabilities

Governance

- ACAT 1D Program – AT&L
- SAE / PEO Reporting
- International Partners
- Flag Level Advisory Groups



GOODS

- Trust & Equities
- Collaborative Leadership
- Lots of Help
- Direct Access
- Stability

OTHERS

- Competing Interests
- “Direction”

Management Tools

- Worldwide Team Connectivity
- Earned Value
- Digital Data Libraries
- Risk and KSDI
- Commercial S/W Tools
- "Linked" Integrated Scheduling (with Critical Path)

GOODS

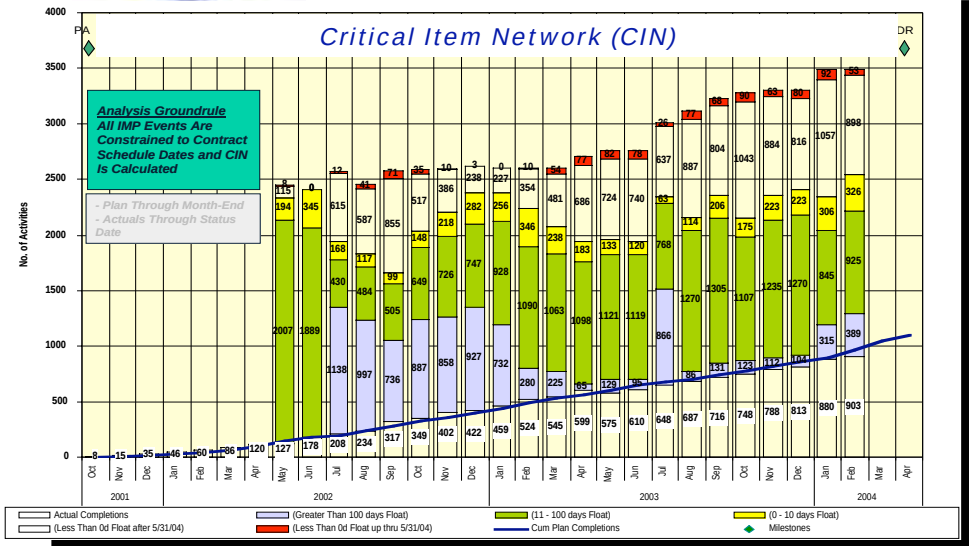
- Master Data
- Engineering Environment
- Configuration Management
- Real time Metrics

OTHERS

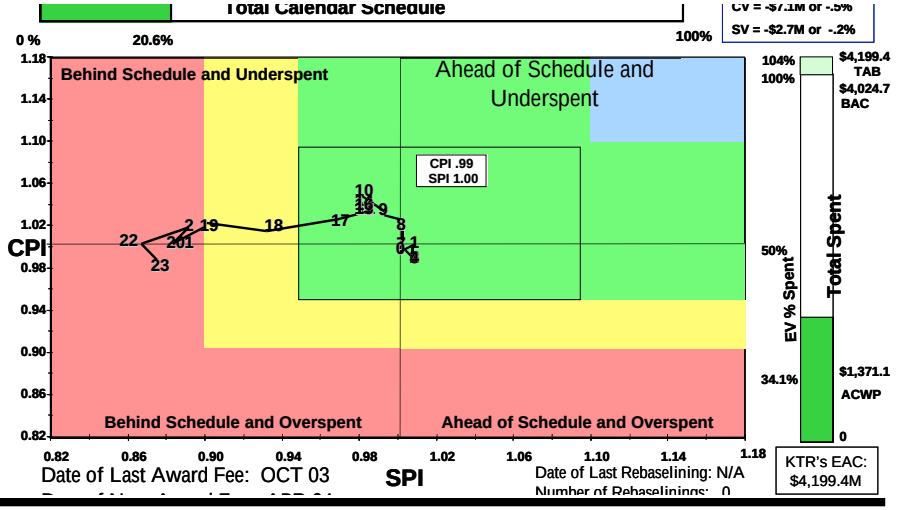
- Data Management/ Entry
- Real Time Metrics
- S/W Versions
- Access

Management Tools

Critical Item Network (CIN)



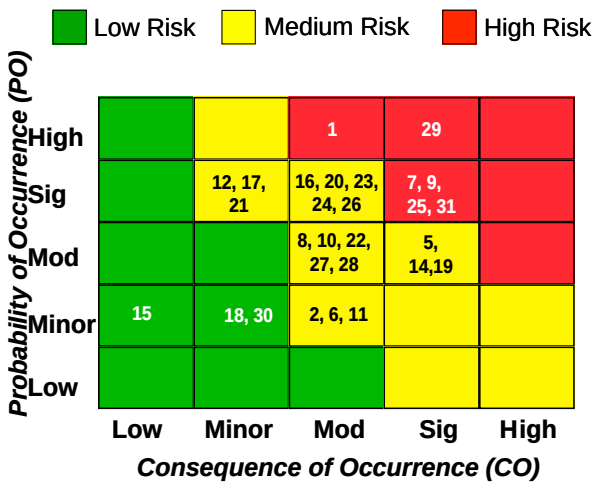
Earned Value Management System (EVMS)



Integrated Management Framework (IMF)

	WBS	DESCRIPTION	SV	CV	VAC	Fmt5Var	BCWS	BCWP	ACWP	SV	SV%	SPI	CV	CV%	CPI	BAC	LRE
1	2000	Autonomic Logi	↑	↔	↔	sC	220,091.8	218,283.8	198,186.1	-1,808.1	-0.82	0.992	20,097.7	9.21	1.101	1,813,567.2	1,849,871.7
2	2100	Autonomic Logi	↔	↔	↔	C	24,299.6	24,095.2	21,044.7	-204.3	-0.84	0.992	3,050.6	12.66	1.145	172,519.2	178,857.1
3	2200	Support Systen	↑	↔	↔	sC	124,941.5	125,053.5	113,380.5	112.0	0.09	1.001	11,673.1	9.33	1.103	966,525.9	993,319.5
4	2300	Training Systen	↓	↔	↔	C	34,907.8	33,335.5	30,176.8	-1,572.3	-4.50	0.955	3,158.6	9.48	1.105	423,375.6	425,303.2
5	2400	Autonomic Logi	↑	↓	↔	C	35,943.0	35,799.6	33,584.1	-143.4	-0.40	0.996	2,215.4	6.19	1.066	251,146.4	252,391.9
	WBS	DESCRIPTION	SV	CV	VAC	Fmt5Var	BCWS	BCWP	ACWP	SV	SV%	SPI	CV	CV%	CPI	BAC	LRE
1	5000	Systems Engin	↓	↔	↔	C	167,103.6	165,804.1	152,532.1	-1,299.5	-0.78	0.992	13,272.0	8.00	1.087	691,130.4	707,859.2
2	5100	Requirement M	↓	↔	↔		5,061.7	5,062.7	4,661.7	1.0	0.02	1.000	401.0	7.92	1.086	17,719.4	18,074.2
3	5200	Air System Inte	↑	↔	↔	C	9,113.5	9,113.6	7,532.1	0.1	0.00	1.000	1,581.4	17.35	1.210	45,533.0	46,670.5
4	5300	Air System Veri	↓	↔	↔	C	12,636.3	12,342.0	10,865.0	-294.3	-2.33	0.977	1,477.0	11.97	1.136	73,329.5	76,037.9
5	5400	Specialty Engin	↓	↓	↔		19,624.1	19,631.7	18,799.8	7.6	0.04	1.000	831.9	4.24	1.044	87,077.8	88,885.8
6	5600	Air System Man	↑	↔	↔	C	12,780.1	12,782.2	11,550.9	2.1	0.02	1.000	1,231.3	9.63	1.107	49,305.0	50,928.1
7	5700	Software Manag	↓	↔	↔	C	31,429.3	31,324.3	27,803.6	-105.0	-0.33	0.997	3,520.8	11.24	1.127	111,308.5	114,018.0
8	5800	Affordability a	↔	↔	↔	C	6,539.2	6,539.2	4,951.5	0.0	0.00	1.000	1,587.7	24.28	1.321	32,868.2	33,554.4
9	5900	Information Arc	↓	↓	↔		7,728.8	7,761.6	7,240.6	32.9	0.43	1.004	521.1	6.71	1.072	30,378.0	30,365.2
10	5A00	Air System Anal	↔	↑	↔	cC	36,099.5	35,155.6	32,801.1	-943.9	-2.61	0.974	2,354.5	6.70	1.072	137,829.3	140,645.8
11	5C00	Subcontract Ma	↔	↓	↔		26,091.3	26,091.3	26,325.8	-0.0	-0.00	1.000	-234.5	-0.90	0.991	105,781.7	108,679.3
	WBS	DESCRIPTION	SV	CV	VAC	Fmt5Var	BCWS	BCWP	ACWP	SV	SV%	SPI	CV	CV%	CPI	BAC	LRE
1	6000	Program Plans	↑	↓	↔	c	298,364.1	296,211.9	290,170.6	-2,152.1	-0.72	0.993	6,041.3	2.04	1.021	1,287,377.3	1,311,803.0
2	6100	Program Plans	↑	↓	↔	c	148,564.1	148,564.1	150,052.7	0.0	0.00	1.000	-1,488.6	-1.00	0.990	663,533.8	686,210.5
3	6200	Business Mana	↔	↑	↑	cC	33,832.0	33,832.0	29,952.6	0.0	0.00	1.000	3,879.3	11.47	1.130	161,728.7	164,905.3
4	6300	Infrastructure	↑	↓	↓	c	69,740.3	67,588.2	69,710.3	-2,152.1	-3.09	0.969	-2,122.1	-3.14	0.970	278,364.3	275,432.4
5	6500	Subcontract Ma	↔	↑	↔		33.9	33.9	50.7	0.0	0.00	1.000	-16.8	-49.57	0.669	3,708.6	3,921.6
6	6600	Program Contr	↔	↓	↓	cC	46,193.7	46,193.7	40,404.2	0.0	0.00	1.000	5,789.5	12.53	1.143	180,042.0	181,333.2

Air System Risk Matrix



01: Software Executability
02: STOVL Lift System Hardware
03: Trained Manpower Availability **(Closed)**
04: Supplier Management **(Closed)**
05: Mission System Fusion Algorithms
06: Deck Crew Environment
07: Production URF
08: Process and Tool Performance
09: Air Vehicle Weight Control
10: EHA Development
11: Canopy Bird Strike Compatibility
12: Requirements Control Under PBS
13: TAA Process Maturity **(Closed)**
14: Interoperability
15: STOVL V-Mil
16: Anti Tamper
17: Multiple Levels of Classification
18: Lift Fan Aeromechanics
19: Air Vehicle Thermal Management
20. Chemical-Biological
21. Classified
22. Classified
23. Engine/Inlet Compatibility
24. Stores Certification
25. AL Footprint Growth
26. Deceleration
27. Internal and External Weapon Separation
28. Maintainer Access And Weapon Loading
29. Integrated Training Center Site Selection
30. EHAS Contribution to SCT/FES Testing
31. MS Block 0.1 Integration

Future … with F-35

- **F-35 Creates Truly Global, Highly Effective Fighter Force**
- **Coalition Package Able to Tackle Heavily Defended Targets**
- **Closes Aerospace "Capability Gap"**

WORKING TO AFFORDABLY MEET THE REQUIREMENTS OF THE WARFIGHTER

1st Space Exploration Conference: Continuing the Voyage of Discovery

John W. Douglass

AIA President & CEO

February 1, 2005

AEROSPACE INDUSTRIES ASSOCIATION

The Aerospace Industry Today

Economy...

Security...

Terrorism...

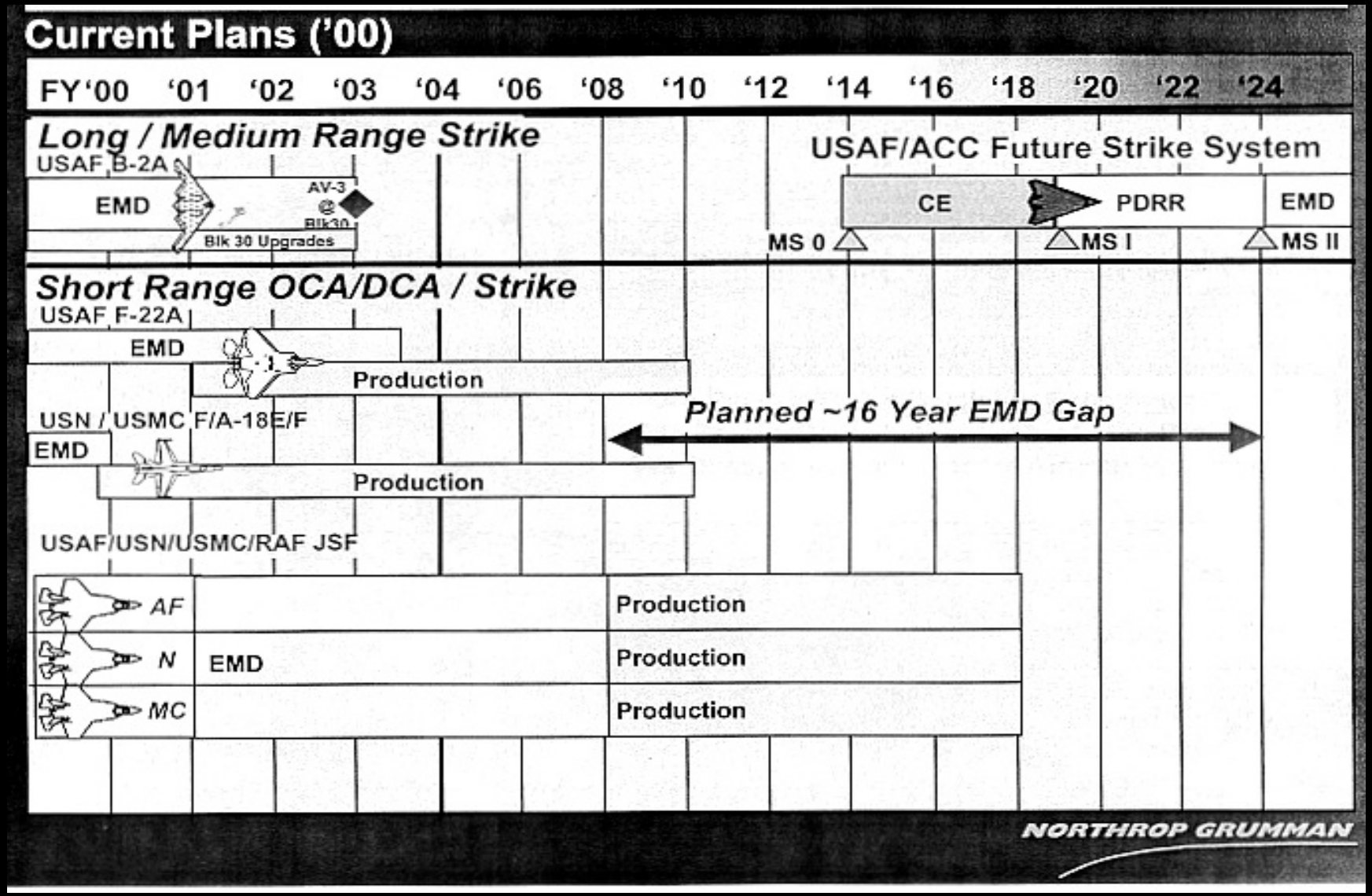
The crisis continues...

But a vision emerges…

Program Management

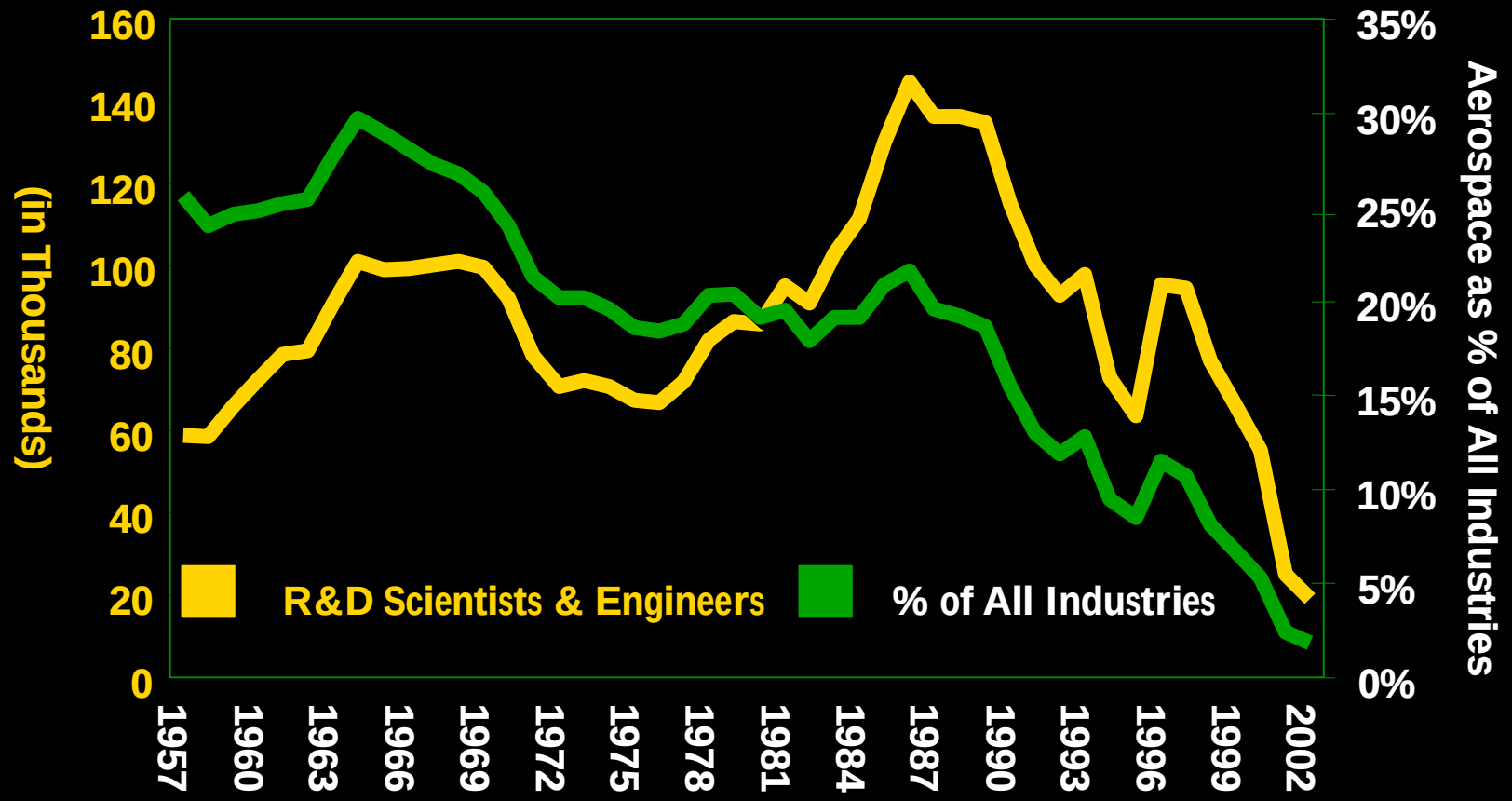
- NASA's long-term programs must be executed in a way that leads to program continuity
- Phasing of programs critical
- Gap between Space Shuttle and Project Constellation (CEV)

DoD Fixed Wing Combat Aircraft Programs



R&D Scientists & Engineers Employment

In Aerospace and as % of all Industries



Educational Support

National plan for educational support

- State & local-based education system
- No industrial planning for aerospace sectors

The Aerospace Commission of the Future of the U.S. Aerospace Industry recommended:

"the nation immediately reversed the decline in, and promote the growth of, a scientifically and technologically trained U.S. aerospace workforce."

"Feast or Famine"

Model of the Future

- Joint Planning & Development Office development of the next-generation air traffic control system

- Cross agency/department development of a complex system
- Aerospace Commission recommendation

The Joint Program Model for Space may be the way ahead for Space Exploration

Conclusion

- America's space industrial base has declined at a time when the global industrial base has broadened.
- Cooperation in space can lead to better programs for all concerned.
- The Space Industrial base must have continuity.

AIA
AEROSPACE INDUSTRIES ASSOCIATION

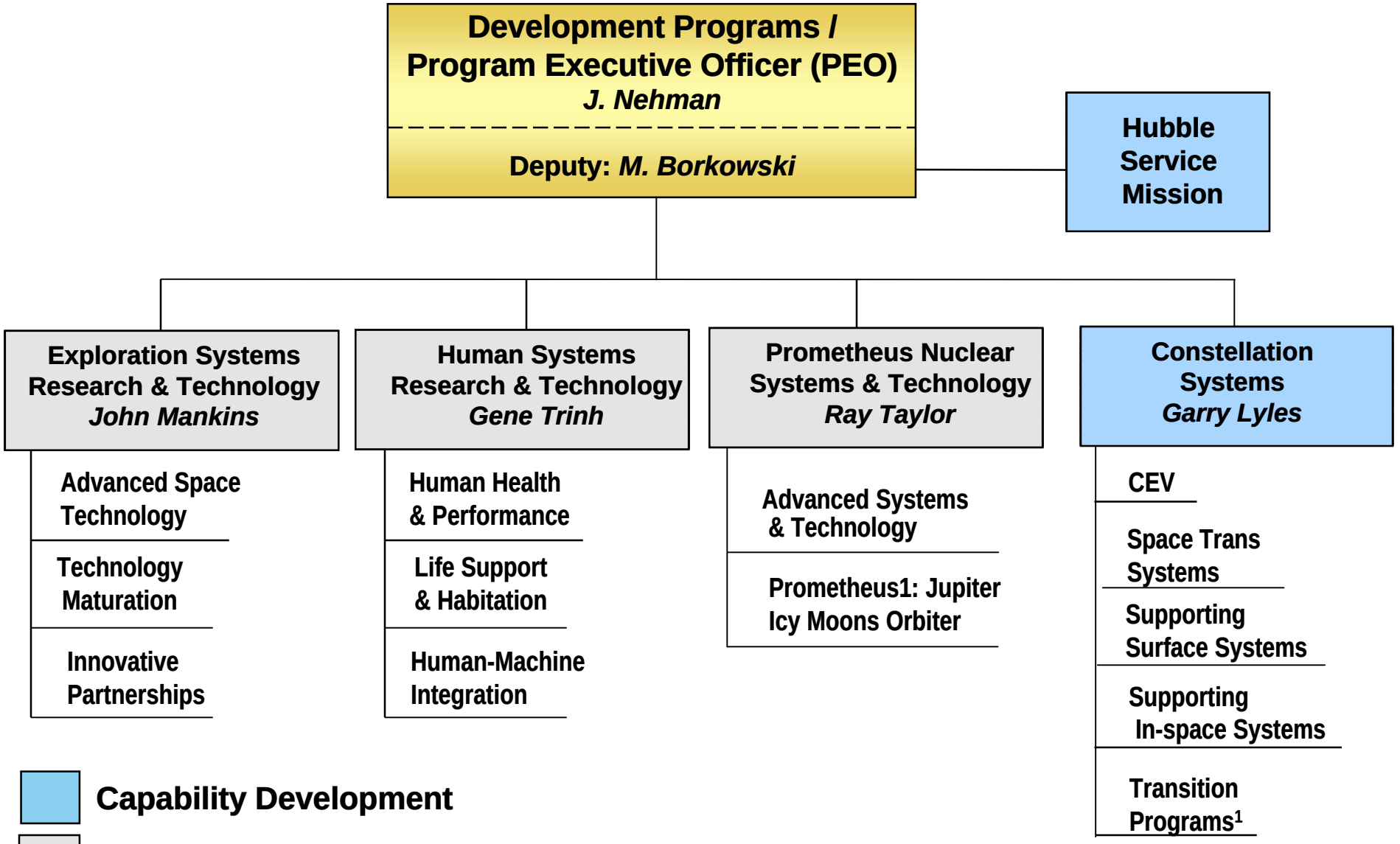
BACK UP – Jim Nehman

Evolutionary Acquisition

- **Spiral Development**: The ***end-state requirements are not known at program initiation***. Those requirements are refined through system development and demonstration, risk management and continuous user feedback

- **Incremental Development**: The end-state requirement is known, and that ***requirement is met over time by developing several increments***, each dependent on available mature technology and resources

Exploration Systems Development Programs



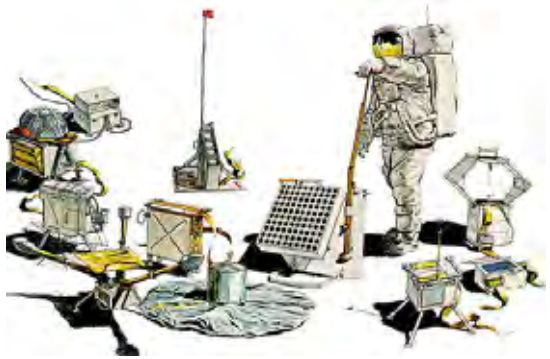
Note 1: X-37, Orbital Express, DART, PAD, NGLT

BACK UP CHARTS – John Mankins

Key Elements of the Nation's Vision

- **Objectives**
  - Implement a sustained and affordable human and robotic program
  - Extend human presence across the solar system and beyond
  - Develop supporting innovative technologies, knowledge, and infrastructures
  - Promote international and commercial participation in exploration

- **Major Milestones**
  - 2008: Initial flight test of CEV
  - 2008: Launch first lunar robotic orbiter
  - 2009-2010: Robotic mission to lunar surface
  - 2011 First Unmanned CEV flight
  - 2014: First crewed CEV flight
  - 2012-2015: Jupiter Icy Moon Orbiter (JIMO)/Prometheus
  - 2015-2020: First human mission to the Moon



Exploration Systems Research and Technology Goals and Objectives

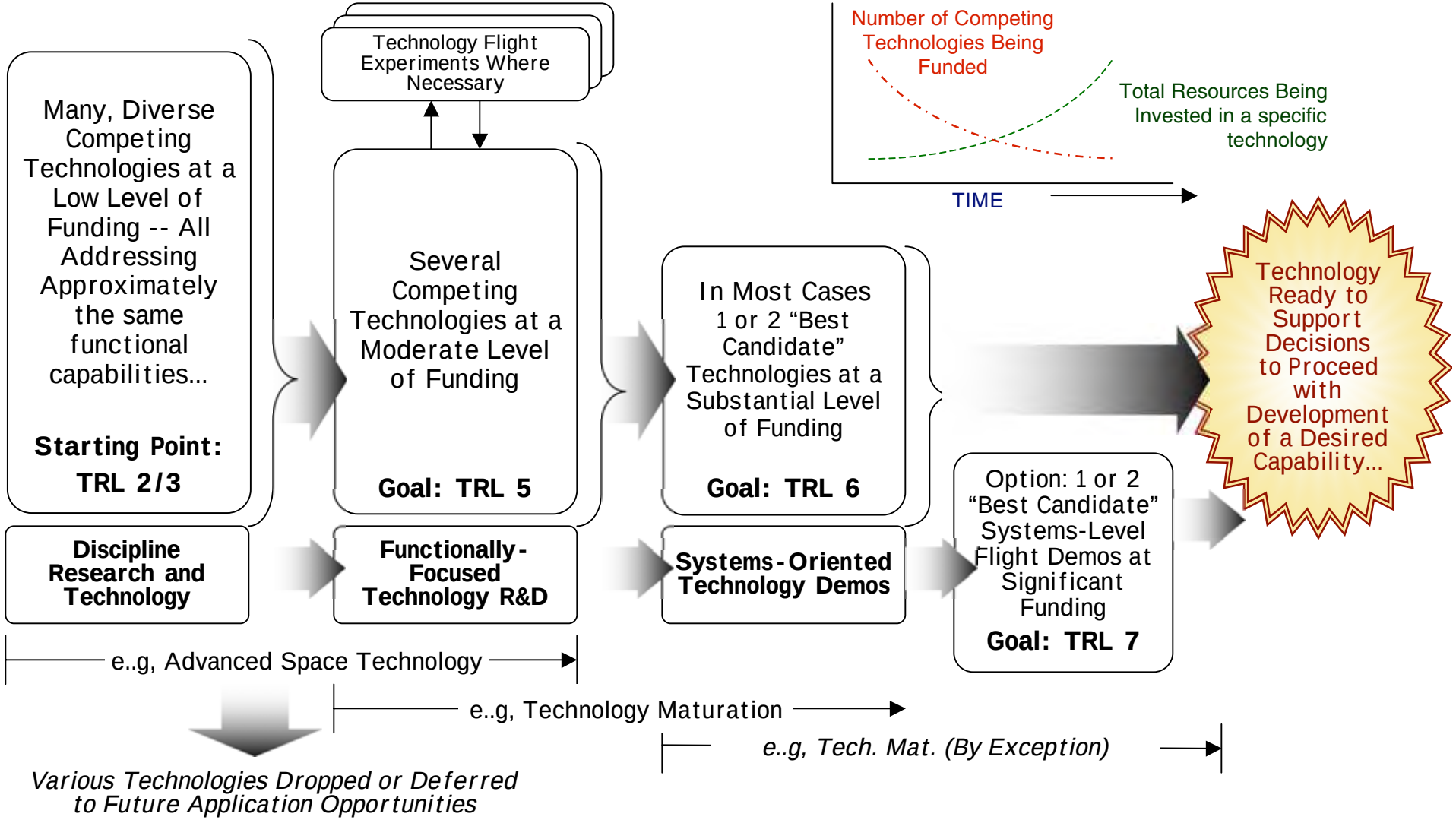
Goal

- **Investments made through the ESR&T programs will provide the critical foundation of knowledge and validated technologies for achieving the Vision for Space Exploration, while delivering technologies of broad common value to NASA, the Nation and the U.S. economy**

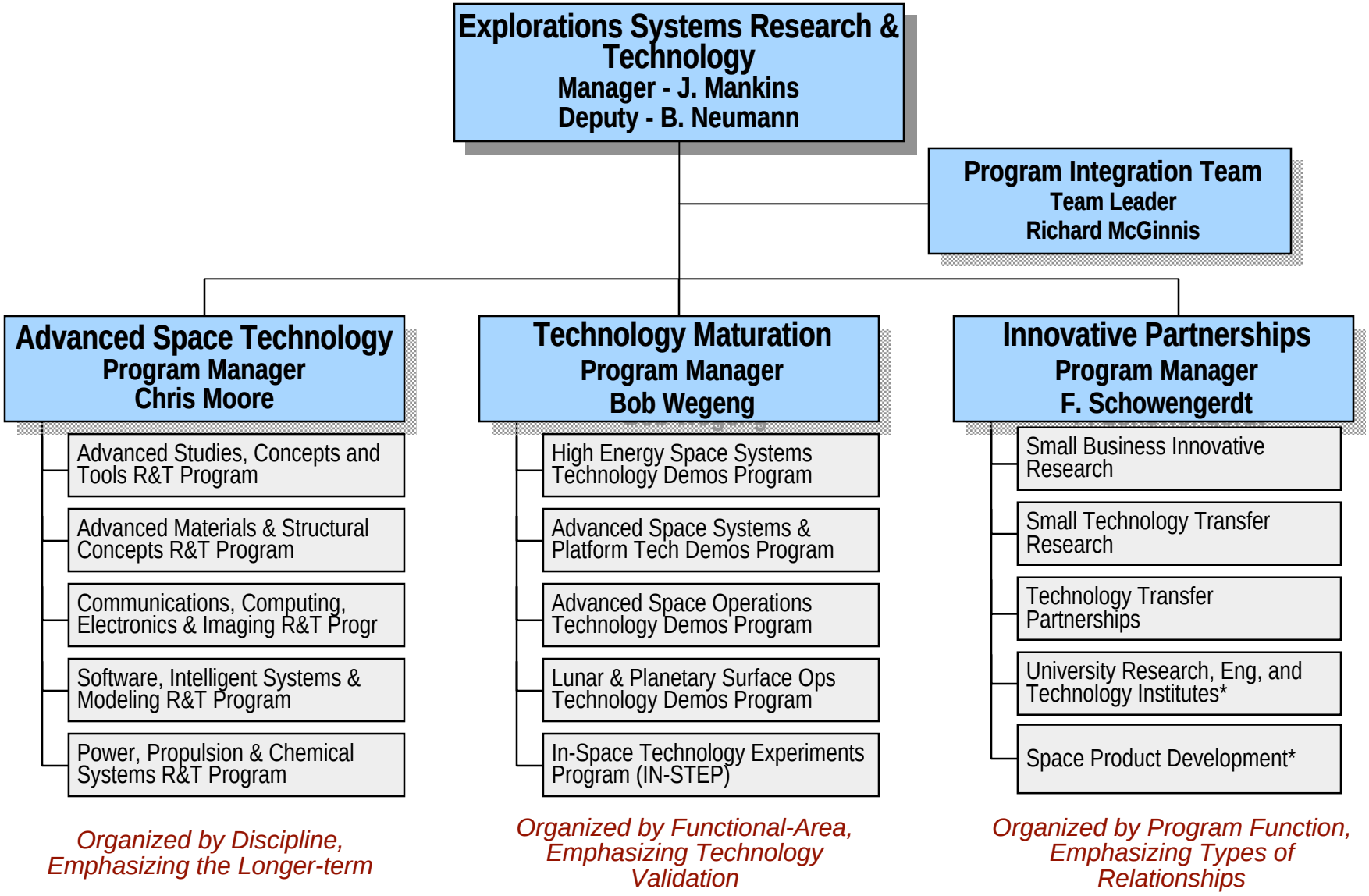
Selected Objectives

- **Establish the viability (or non-viability) of various major systems and systems-of-systems options for longer-term future exploration systems, with a focus in the next 6-9 years on the systems-of-systems level issues that will determine how we return to the Moon by no later than 2020**
- **Address critical gaps in needed capabilities and/or technologies that emerge during definition of the systems that ESMD will 'build next'—for example, for "Spiral 1"**
- **Develop, demonstrate and deliver component-, subsystem-, or system-level technologies for consideration by system developers that may provide an substantial improvement to chosen technologies**
- **Develop, demonstrate and transfer technologies of broad common value, for NASA, other government and for the benefit of the economy**
- **Assure the timely creation and effective management of innovative and partnerships to accomplish better exploration, science and technology goals**

Exploration Systems Research & Technology
Strategic Technology/Systems Model



Exploration Systems Research & Technology Organization

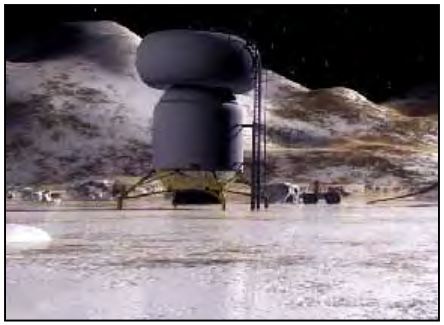


Organized by Discipline, Emphasizing the Longer-term

Organized by Functional-Area, Emphasizing Technology Validation

Organized by Program Function, Emphasizing Types of Relationships

Exploration Systems Research & Technology
Advanced Space Technology Program (ASTP)



Salient Features:

- Pursues novel systems concepts
- Conducts research in low TRL exploration R&D areas
- Advanced promising technologies from TRL 3 to TRL 5
- Addresses technologies with the potential to enable ‘system-of-systems’ level innovations in the next 10-20+ years
- Discipline-organized: focusing on major challenges in discipline research areas

Element Programs

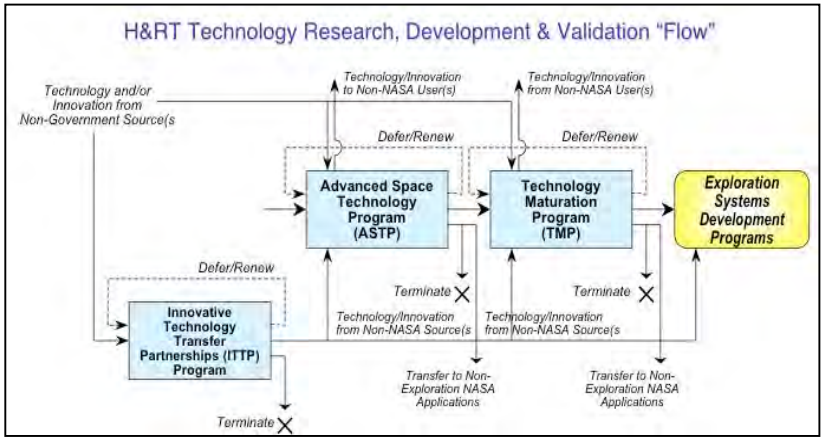
- Advanced Studies, Concepts and Tools
- Advanced Materials and Structural Systems
- Computing, Communications, Electronics and Imaging
- Software, Intelligent Systems and Modeling
- Power, Propulsion and Chemical Systems

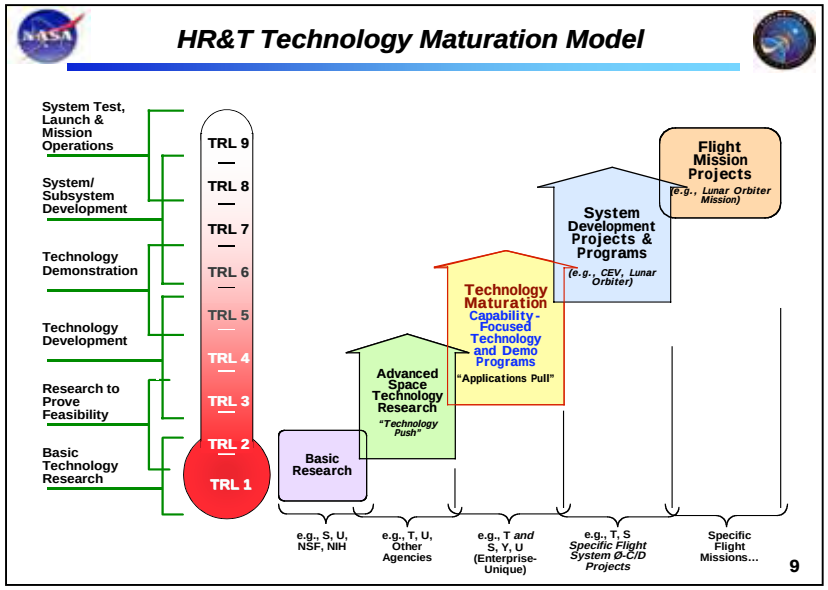
Salient Features:

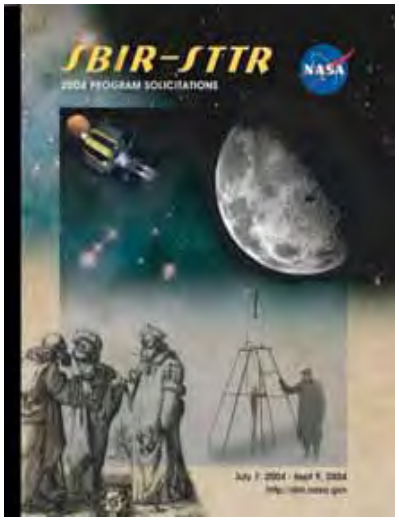
- Matures new technologies from TRL 4 to TRL 6 (or higher, as appropriate)
- Addresses technologies with the potential to enable 'system-of-systems' level innovations in the next 5-10 years
- Functionally-organized: focusing on major challenges in future capabilities

Element Programs

- High Energy Space Systems
- Advanced Space Platforms and Systems
- Advanced Space Operations
- Lunar and Planetary Surface Operations
- In-Space Technology Experiments Program







Salient Features:

- Establishes partnerships among NASA programs and external innovators
- Develops and protects NASA Intellectual Property
- Transfers technology into NASA programs / from NASA programs

Element Programs:

- Small Business Innovation Research (SBIR) Program
- Small Business Technology Transfer (STTR) Program
- Technology Transfer Agents
- University Research, Engineering and Technology Institutes
- Research Partnership Centers