On the Occasion of
the 100th Anniversary of the Founding of NACA

Epochs of Space Technology at NASA:
The Legacy of the National Advisory Committee on Aeronautics within the Office of Advanced Research & Technology and Beyond

at a Commemorative Symposium at the US Air & Space Museum
Washington, DC
2-3 March 2015

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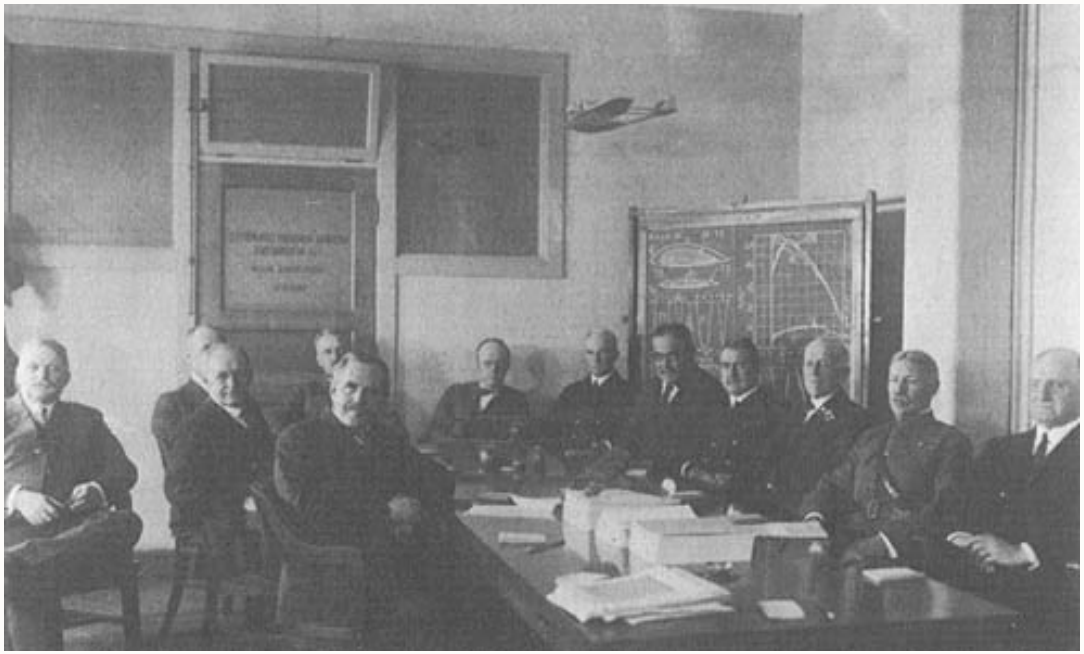
Introduction (1 of 2)

- At its founding in 1958, the National Aeronautics and Space Administration (NASA) incorporated within itself several powerful legacies from earlier years (e.g., JPL and the von Braun organization)
- Also included was the Washington, D.C. organization that had been the National Advisory Committee on Aeronautics (NACA), and the Research Centers that had been a part of the NACA
  - Langley Research Center
  - Lewis Research Center (now the Glenn Research Center), and
  - Ames Research Center
  - Flight Research Center (now the Dryden Flight Research Center)
- For decades afterwards, this “NACA-Heart” within NASA was the one organization with overall leadership responsibility for advanced technology R&D to enable more ambitious future US Space Program, as well as other government and private sector space mission applications

Introduction (2 of 2)

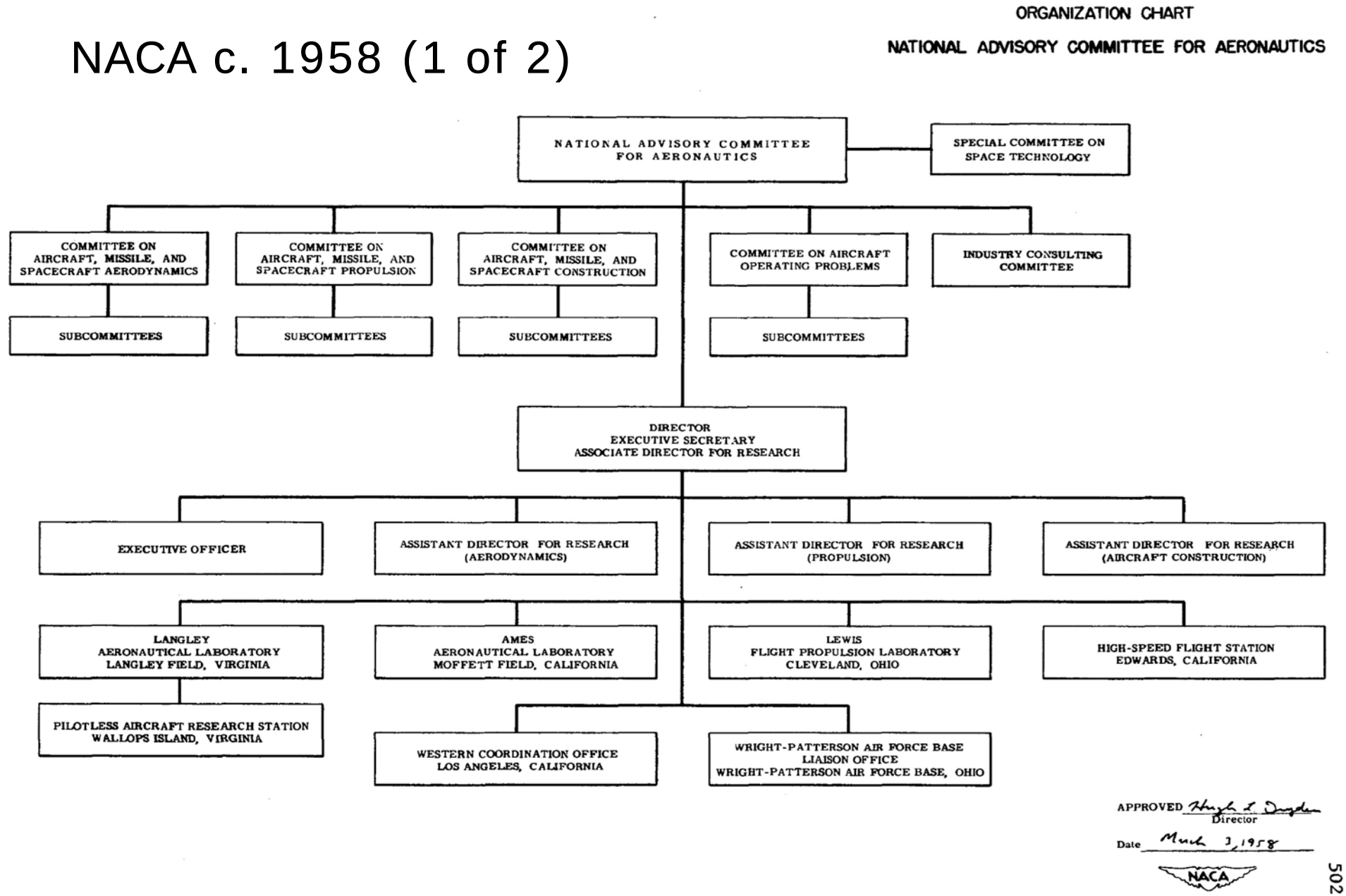
- For much of NASA's history, the responsible organization was the Office of Advanced Research and Technology (OART), which was later renamed as the Office of Aeronautics and Space Technology (OAST).
- This presentation sketches some perspectives on the legacy of the NACA within the NASA Headquarters organization, including
  - What was the NACA Model? An innovation management perspective on its key characteristics
  - What were some of the central elements of NACA Legacy within NASA during following its formation
  - Key programmatic challenges and opportunities during these years and responses of the OART / organization and NASA to those challenges
  - The eventual end of the "NACA Model" and the current practice of innovation at NASA
  - *The principal focus is on the space technology R&D side, rather than on the aeronautics side…*

NACA at the Beginning

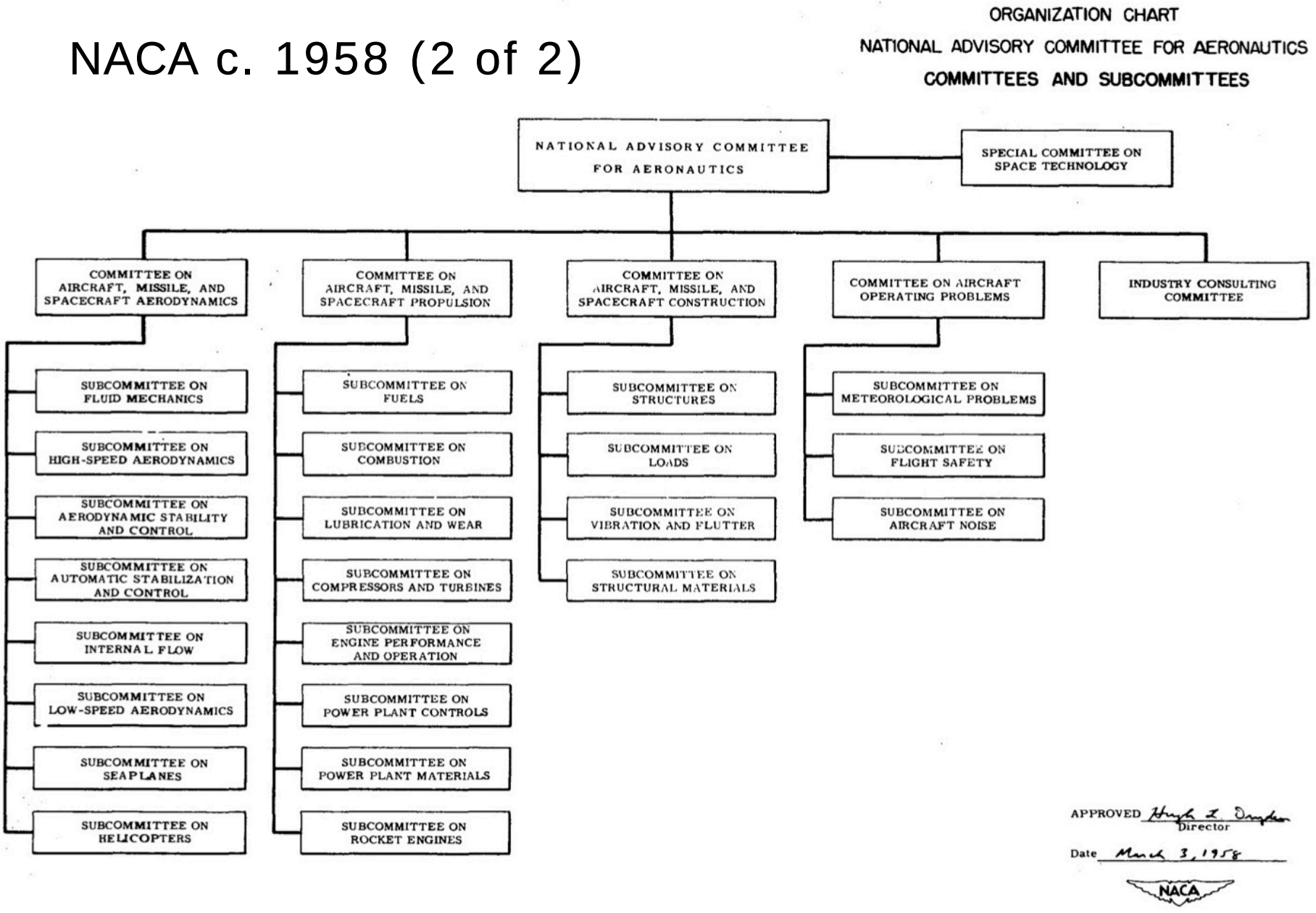


Purpose: "to supervise and direct the scientific study of the problems of flight, with a view to their practical solutions."

NACA c. 1958 (1 of 2)



NACA c. 1958 (2 of 2)



NASA Beginnings

Partial Continuation of the "NACA Model" for Innovation

- At the end of an intensive year, a major reorganization was announced in November 1961 – one element of which was the creation of a new "Office of Advanced Research and Technology" (OART).
- As noted in NASA SP-4102 "Managing NASA in the Apollo Era" (Chapter 3), in that reorganization *"…four (new offices) were created:*

  – *Space Science under Homer Newell,*
  – *Advanced Research and Technology (OART) under Ira Abbott,*
  – *Manned Space Flight (OMSF) under Brainerd Holmes, and*
  – *Applications under Morton J. Stoller.*

- *Also, "an Office of Tracking and Data Acquisition (OTDA) headed by Edmund C. Buckley was established for agency wide support in telemetry and automatic data processing…"*

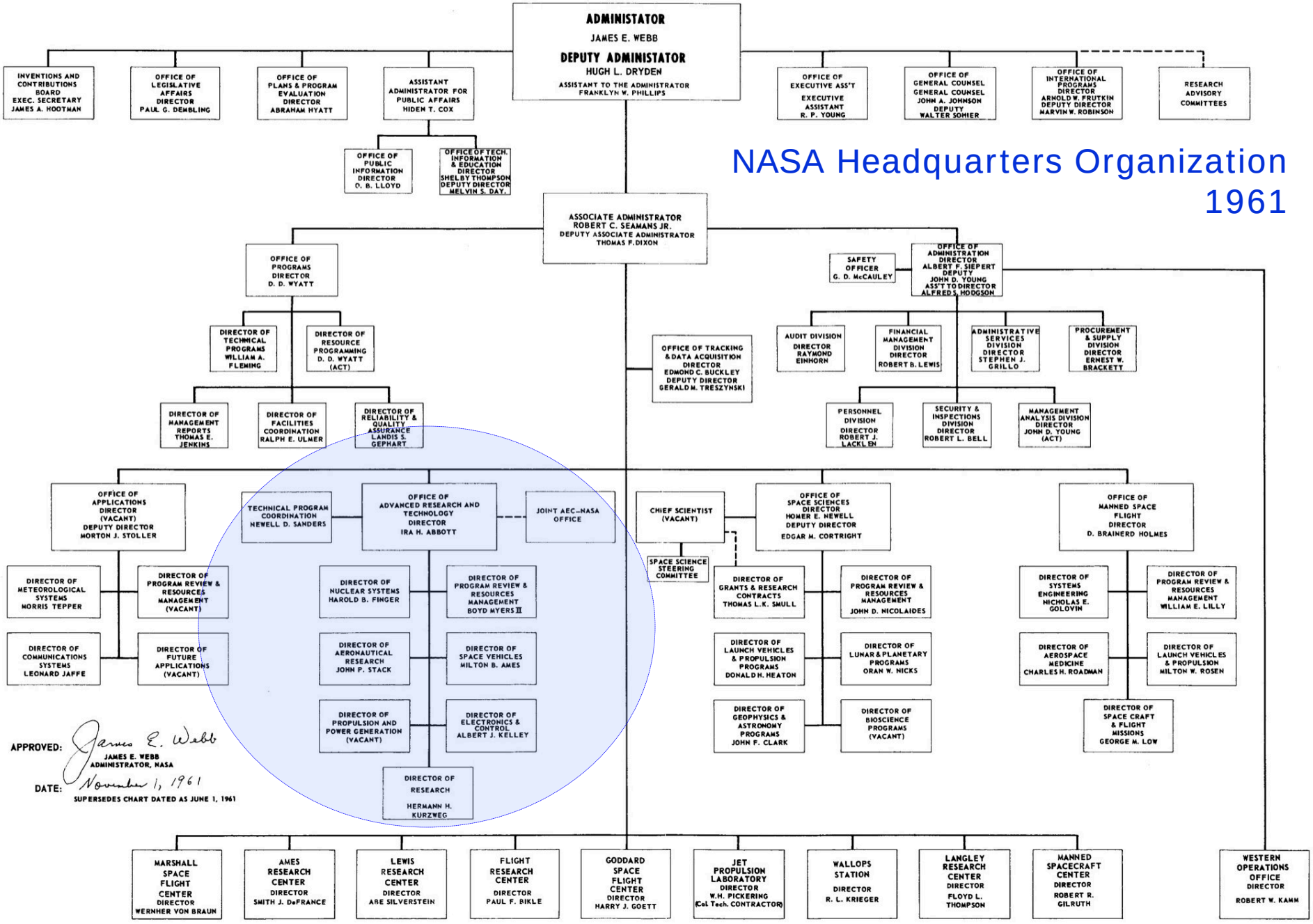
Space Technology at NASA

What Were It's Technical Objectives?

- Space Mechanics
- Space Environment
- Energy Sources
- Propulsion Systems
- Vehicle Configuration and Structure
- Materials
- Launch, Rendezvous, Re-entry, and Recovery
- Communication, Navigation, and Guidance
- Space Biology
- Flight Simulation
- Measurement and Observation Techniques

1958 NACA Planning…

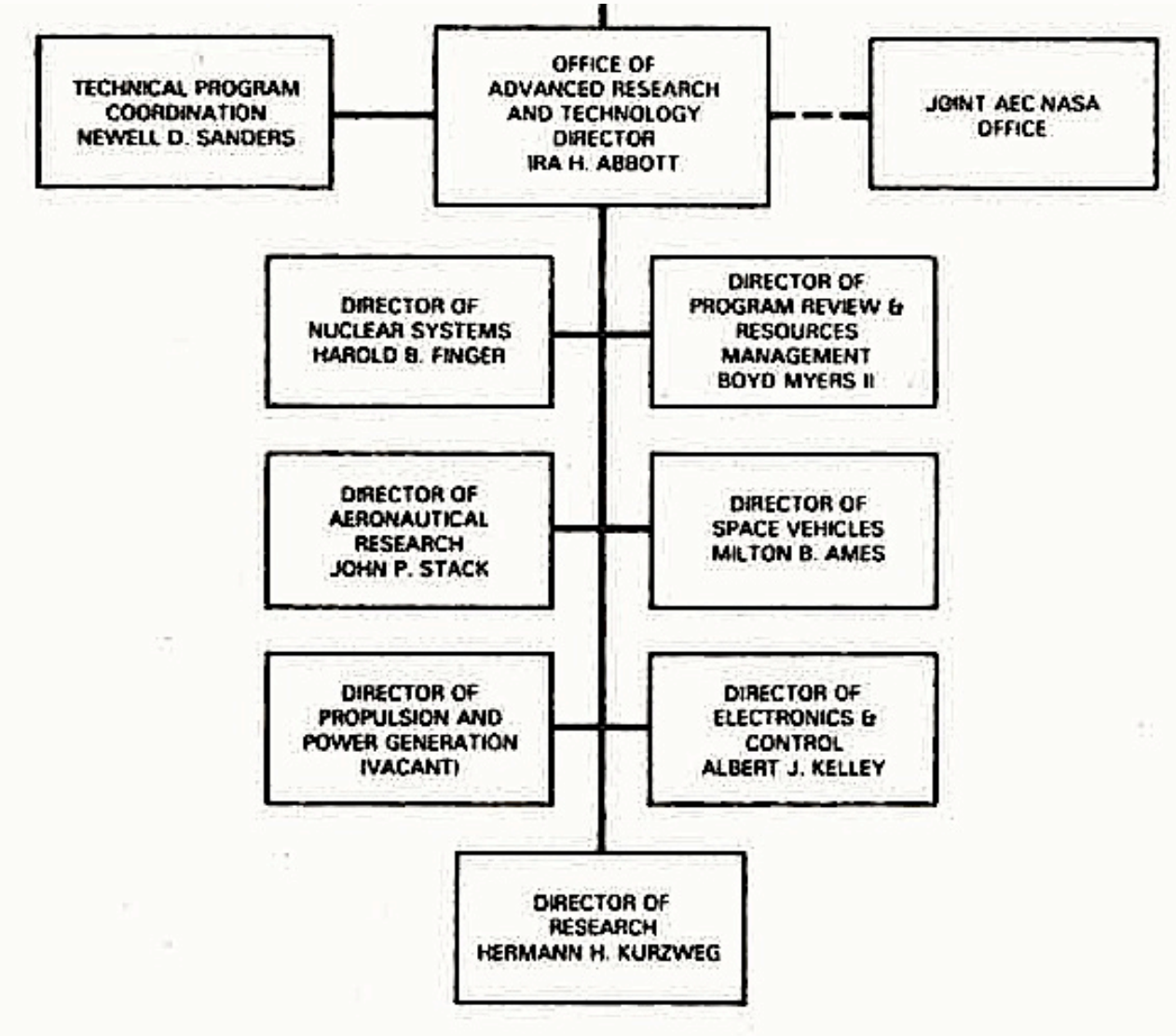
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION



NASA Headquarters Organization 1961

GPO 920431

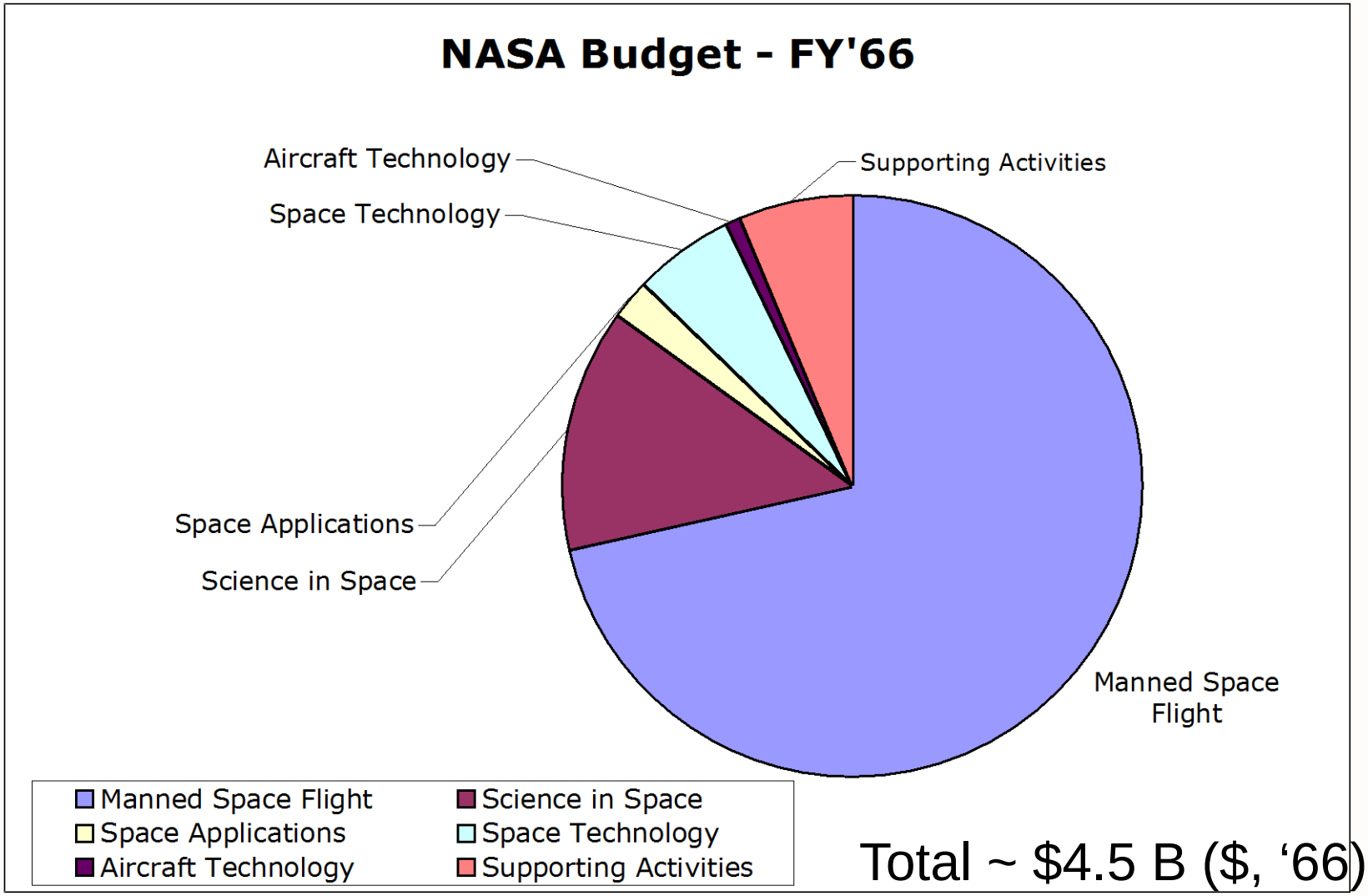
OART Organization 1961



OART During the 1960s

- The OART organization was tasked with developing new technologies for the future of the US Space Program, as well as with helping to solve urgent technical challenges for the ongoing effort to reach the Moon
- All budgets were strong, initially, and the balance of effort shifted dramatically to space technology
  - See Next Slide…
- Key individuals were “plucked” from the NACA / OART organization to support
- During the Apollo-era, there were a number of organizational changes and realignments
- For OART, these changes included
  - Sometimes the NACA Field Centers reported to OART, sometimes not…
  - Sometimes the OART organization separated Aeronautics from Space, sometimes not… (particularly at the end of the Apollo era)

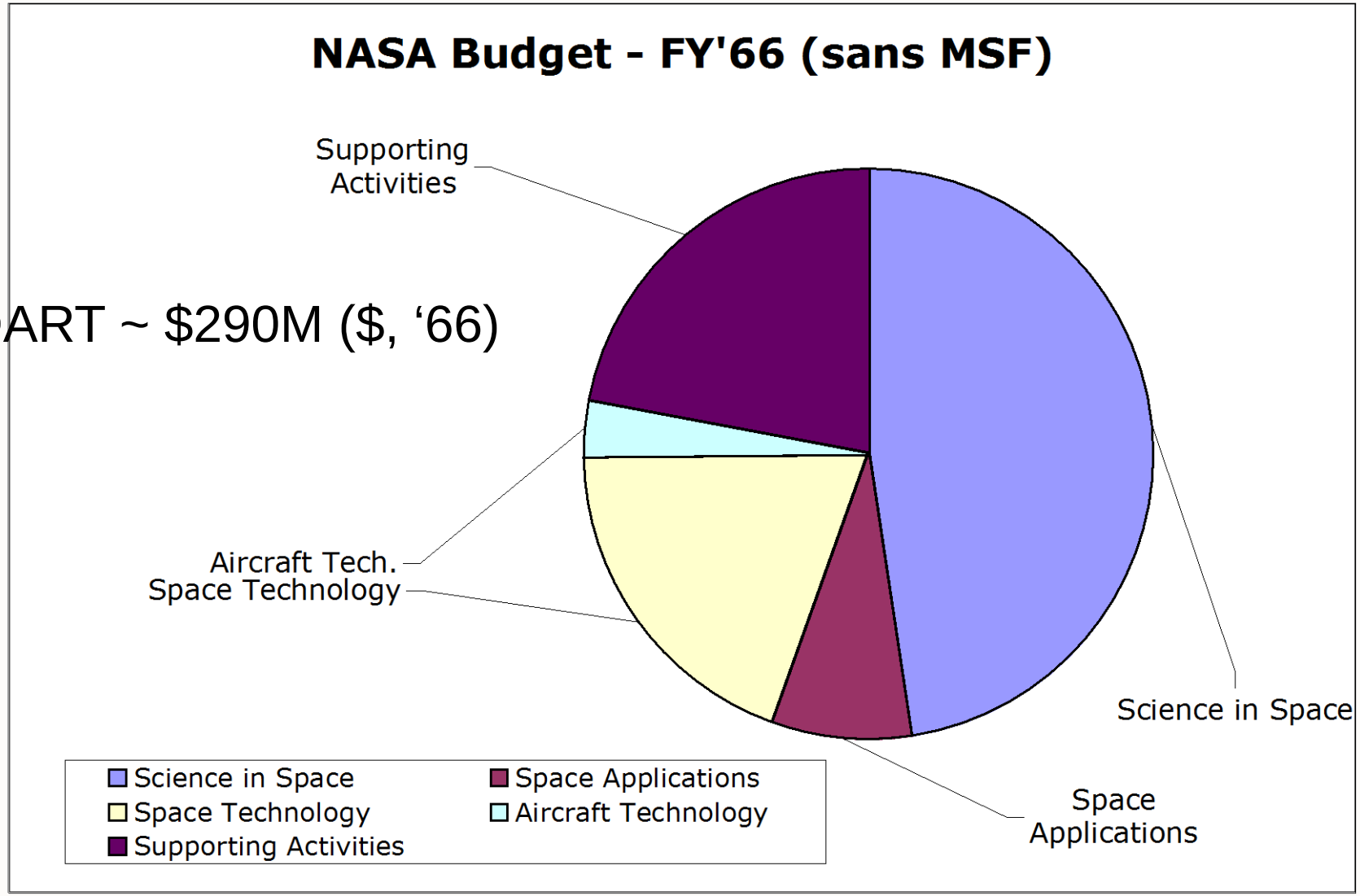
NASA Budget Comparisons
1966 (1 of 2)



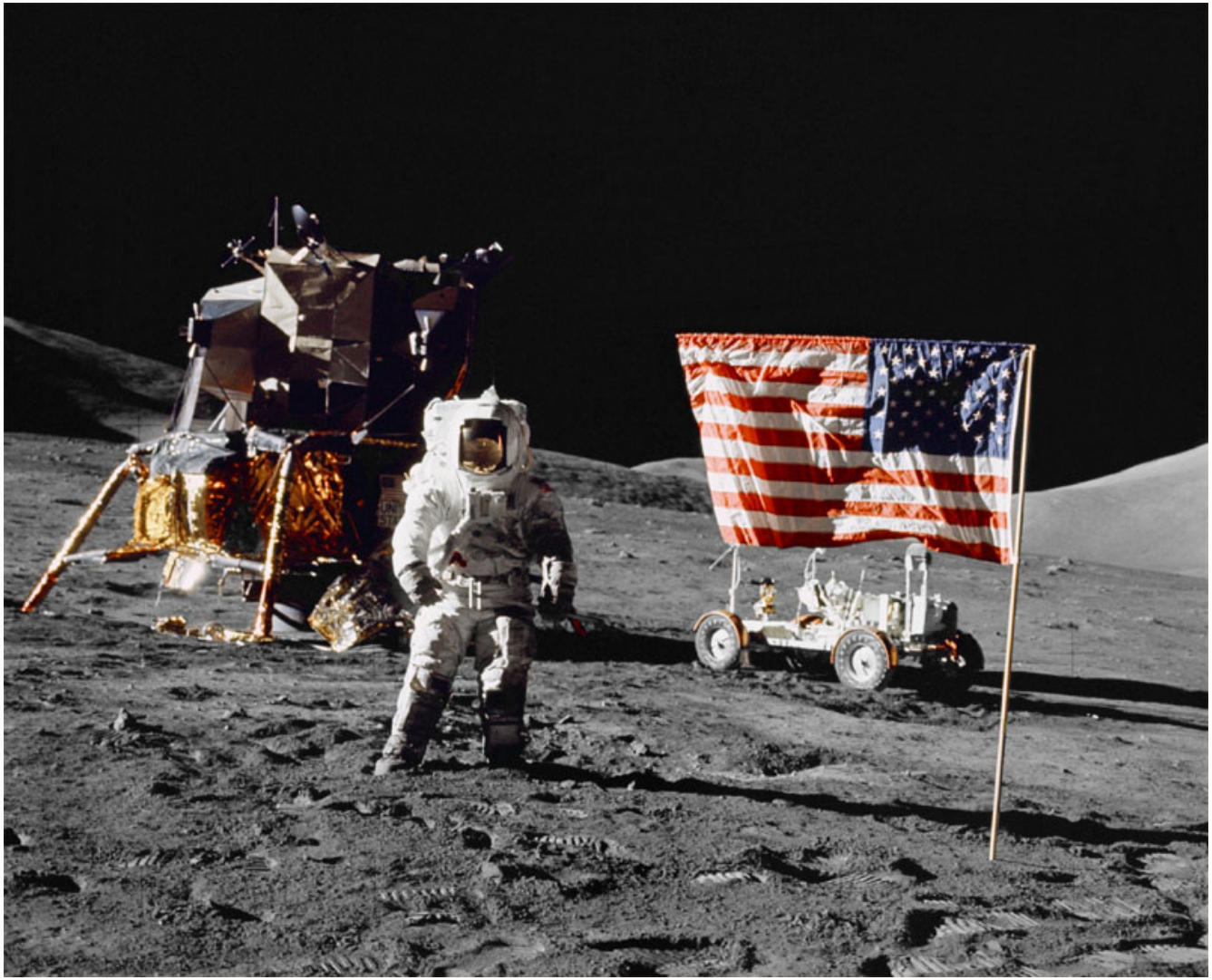
Total ~ $4.5 B ($, '66)

NASA Budget Comparisons 1966 (2 of 2)

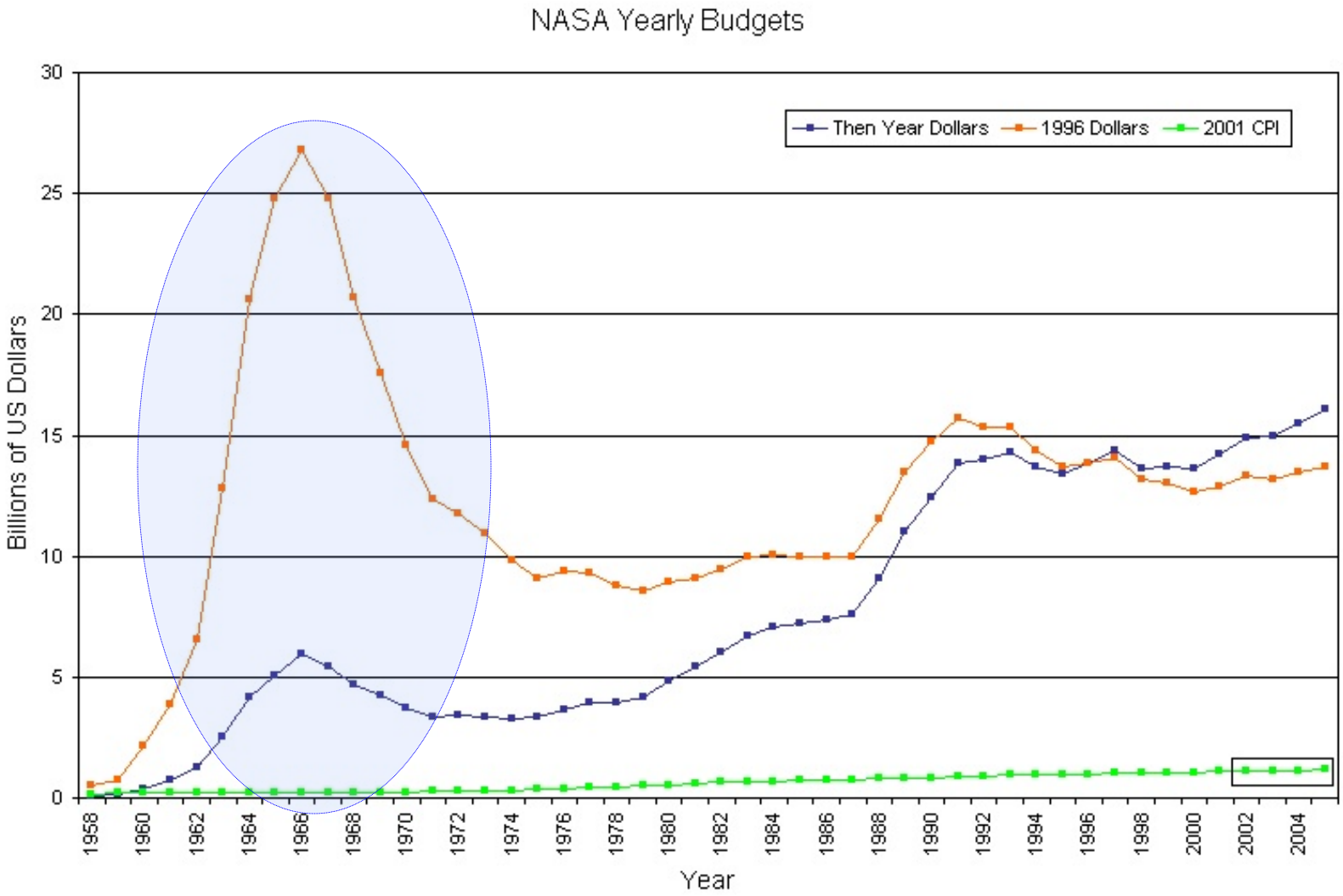
OART ~ $290M ($, ‘66)



1969: Success



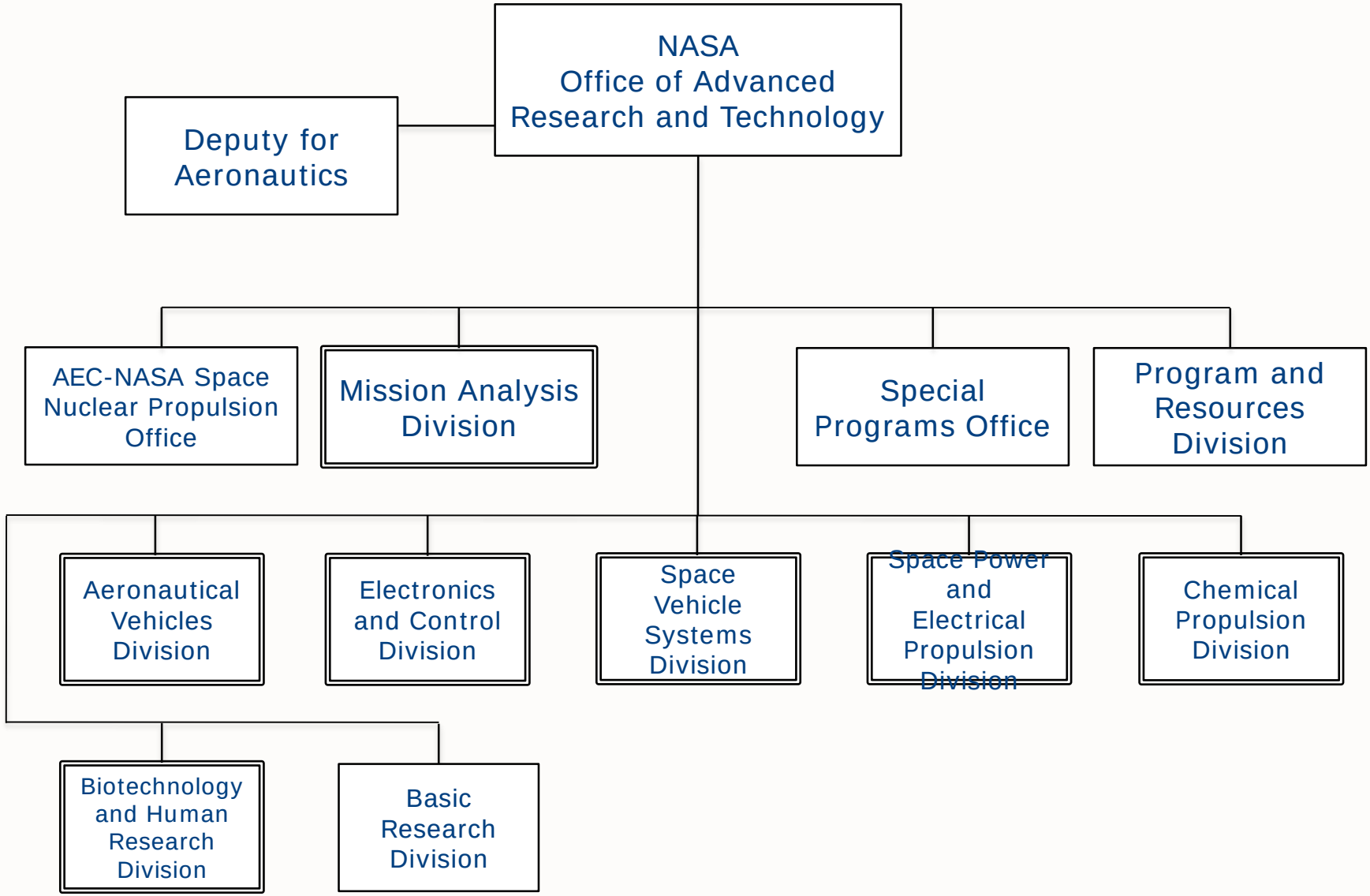
NASA Budget Overview 1958-2005
The End of the Apollo Era



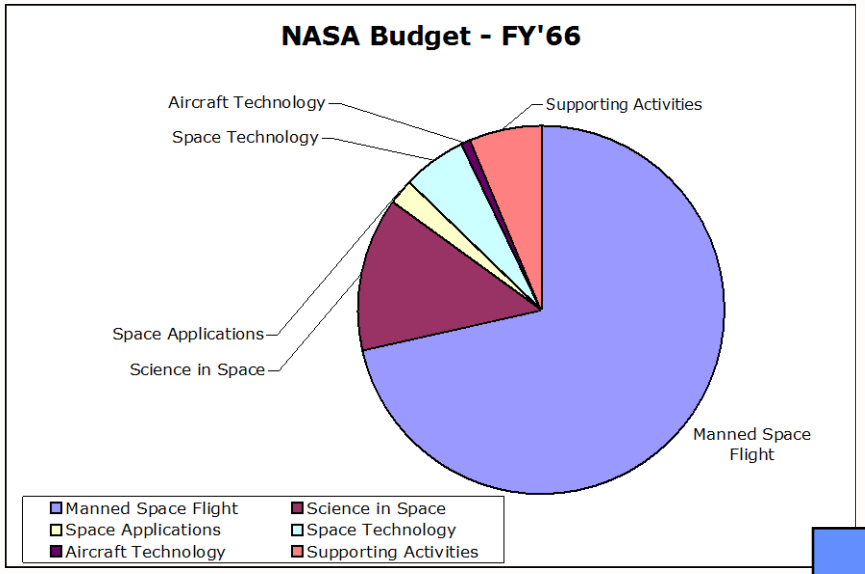
Major Transitions: 1966-1973

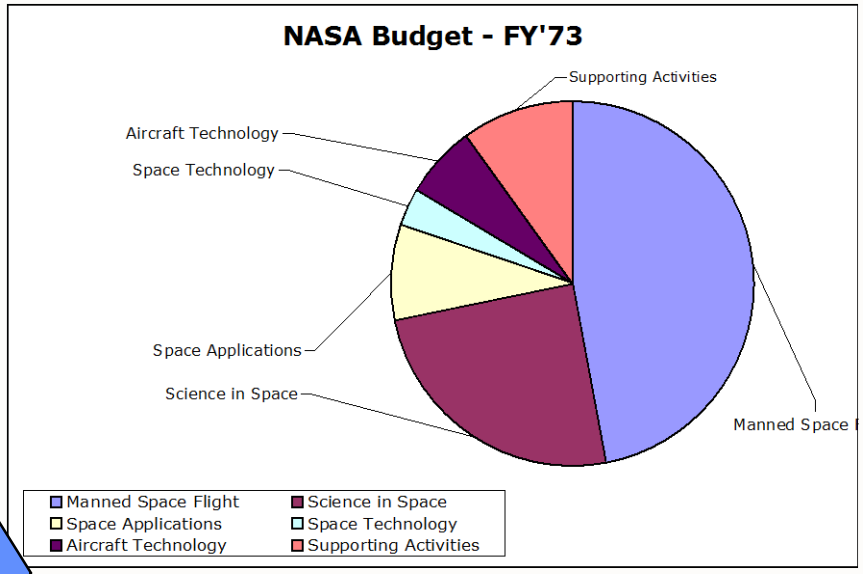
- It is well-known that NASA experience wrenching transitions during the latter years of the 1960s and the early years of the 1970s…
- As the Apollo Program was terminated by the Nixon Administration and the Space Shuttle Program was started, the overall NASA's budget dropped precipitously
- NASA's advanced technology budgets did not decline in proportion to the decreases in the overall budget
- However, there was a significant shift in the balance of investments in OART--and in the role of the organization within NASA…

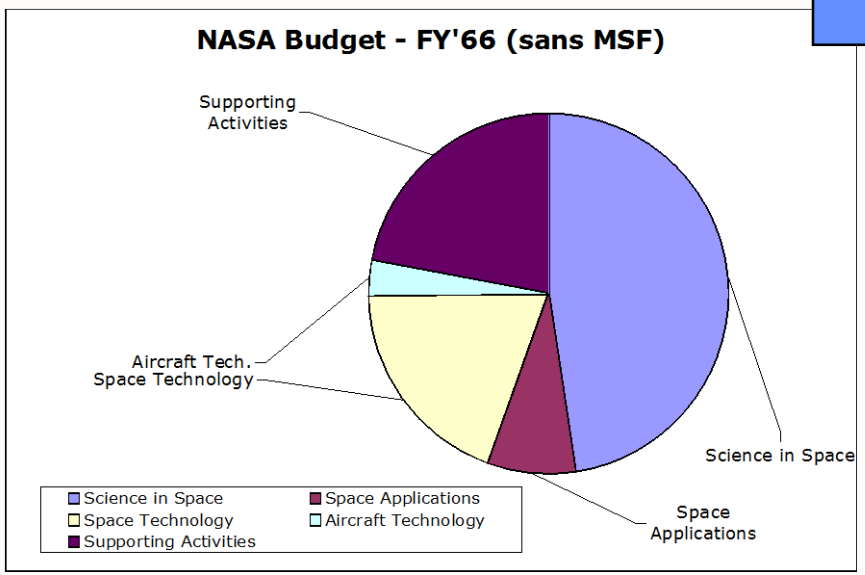
NASA OART - 1969

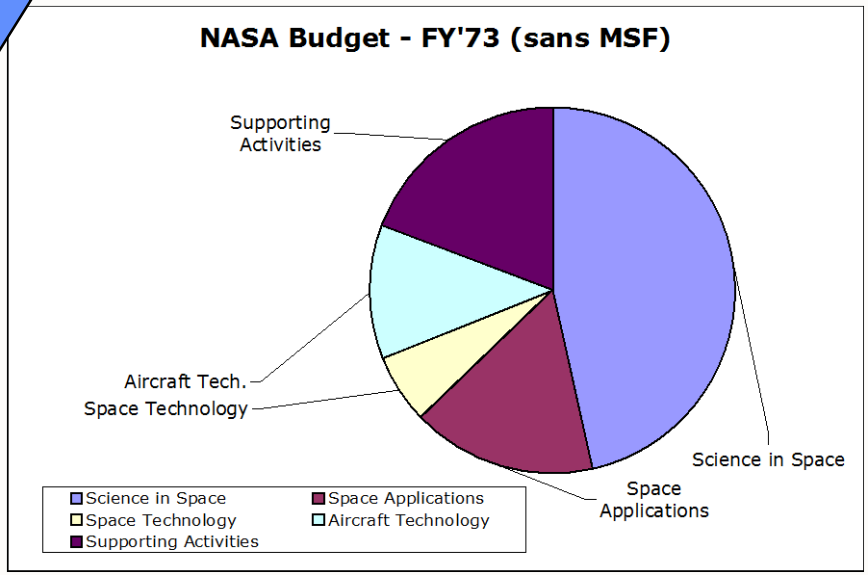


Budget Comparisons: 1966-1973

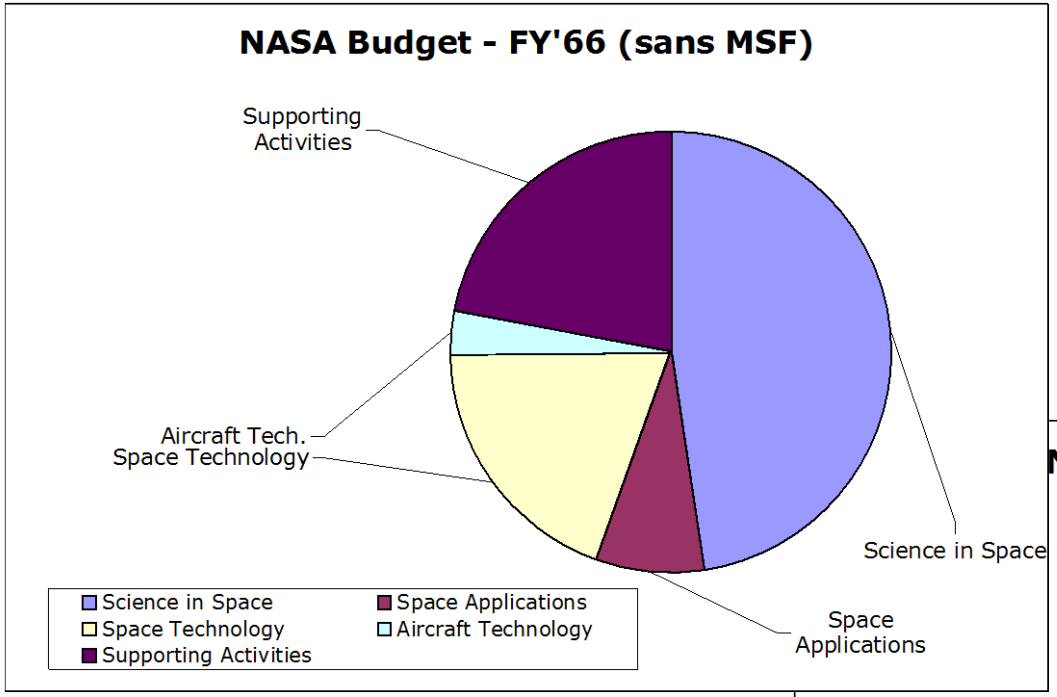


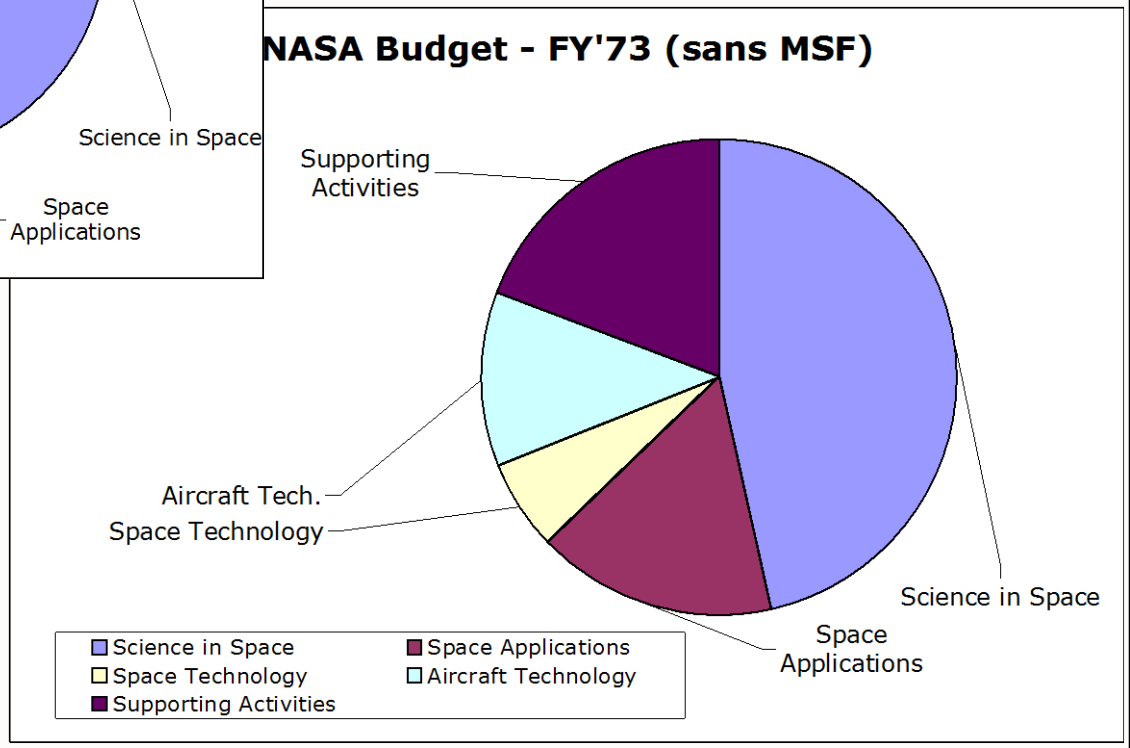






Budget Comparisons: 1966-1973





1966-1973 NASA / OART Budget Overview

	1966	1967	1968	1969	1970	1971	1972	1973
OART '15 $ vs. Then-Year $								
OART Then-Year $, M	290	270	329	278	272	262	213	251
OART 2015 $, M	2,152	1,942	2,273	1,827	1,686	1,558	1,230	1,361
	1966	1967	1968	1969	1970	1971	1972	1973
NASA '15 $ vs. then-Year $								
NASA Then-Year $, M	4,483	4,175	4,385	3,201	3,114	2,542	2,508	2,601
NASA 2015 $, M	33,277	30,210	30,288	21,022	19,280	15,117	14,477	14,128
	1966	1967	1968	1969	1970	1971	1972	1973
OART vs. NASA								
Percentaage	6.47%	6.47%	7.50%	8.68%	8.73%	10.31%	8.49%	9.65%

- In 1966, NASA OART represented an investment in FY 2015 dollars of some $2.2 Billion out of a total of almost $33B
  - In FY 1966 dollars, $290M out of ~ $4.5B
- By 1973, the total for NASA had dropped by more than 50% to just less than $2.6B, while the total for OART (by then OAST) had only dropped by 14% to ~$250M
  - OART (then OAST) had grown from 6.5% to more than 9.6%, as a share of the NASA budget
- This relative strength in OART/OAST budgets was due entirely to the emergence of a much stronger investment in aeronautics technology R&D
  - Another Legacy of NACA within NASA

Changing Objectives
1966 OART's Objectives (1)

- In the winter of 1966-1967, the President's FY 1968 Budget for NASA described the Office of Advanced Research and Technology (OART) as an:

  "…effort required to provide the fundamental knowledge and the technological base for future aeronautics and space programs"

- Further, the NASA FY 1968 Budget Estimates document described the OART effort in somewhat more detail as:

"(A) continuing program aimed at providing the technological base for significant future aero-space missions.

This effort (covered) the spectrum of activity from basic research to improve our fundamental scientific knowledge, through applied technology to improve our practical capability for developing advances systems applicable to space and aeronautical activity."

Changing Objectives
1966 OART's Objectives (2)

- The program (proposed for 1968) included…
  - Basic Research
  - Space Vehicle Systems
  - Electronics Systems
  - Human Factor Systems
  - Space Power & Electric Propulsion Systems
  - Nuclear Rockets
    - OARTs Nuclear Rockets Program was a joint effort between NASA and the AEC (Atomic Energy Commission), managed by a single office, the Space Nuclear Propulsion Office that had been established by an inter-agency agreement between the two organizations.
  - Chemical Propulsion
  - Aeronautics

Changing Objectives
1973 OAST Objectives (1)

- By the winter of 1966-1967, the President's FY 1968 Budget for NASA described the renamed Office of Aeroanutics and Space Technology (OAST) as:

  "A sustained effort providing the fundamental knowledge and technological base for future aeronautics and space programs."

- Further, the FY 1973 Budget Estimates document characterized the OART effort in more detail, and showing clearly the shift in priorities. The document stated:

  "The FY 1973 budget request provides for a major increase in aeronautics research and technology effort aimed at maintained U.S. leadership in aviation, meeting urgent domestic requirements, and supporting military aircraft development. A concentrated effort focuses on a short take-off and landing (STOL) experimental transport aircraft."

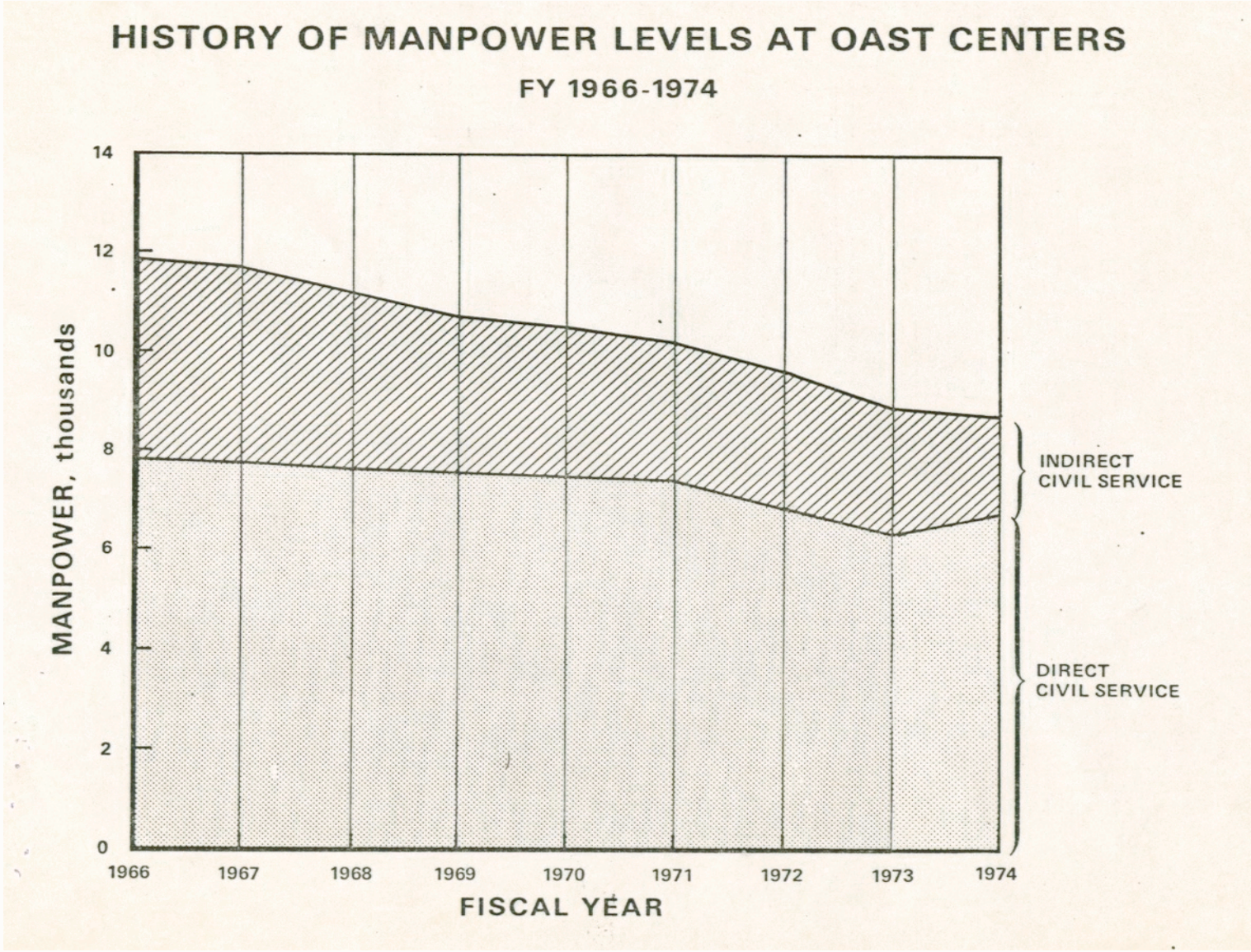
Changing Objectives
1973 OAST Objectives (2)

The program addressed…

- Aeronautical Research and Technology
- Space Research and Technology
- Nuclear Power and Propulsion.
  - Which had been restructured to include low TRL research and studies only…

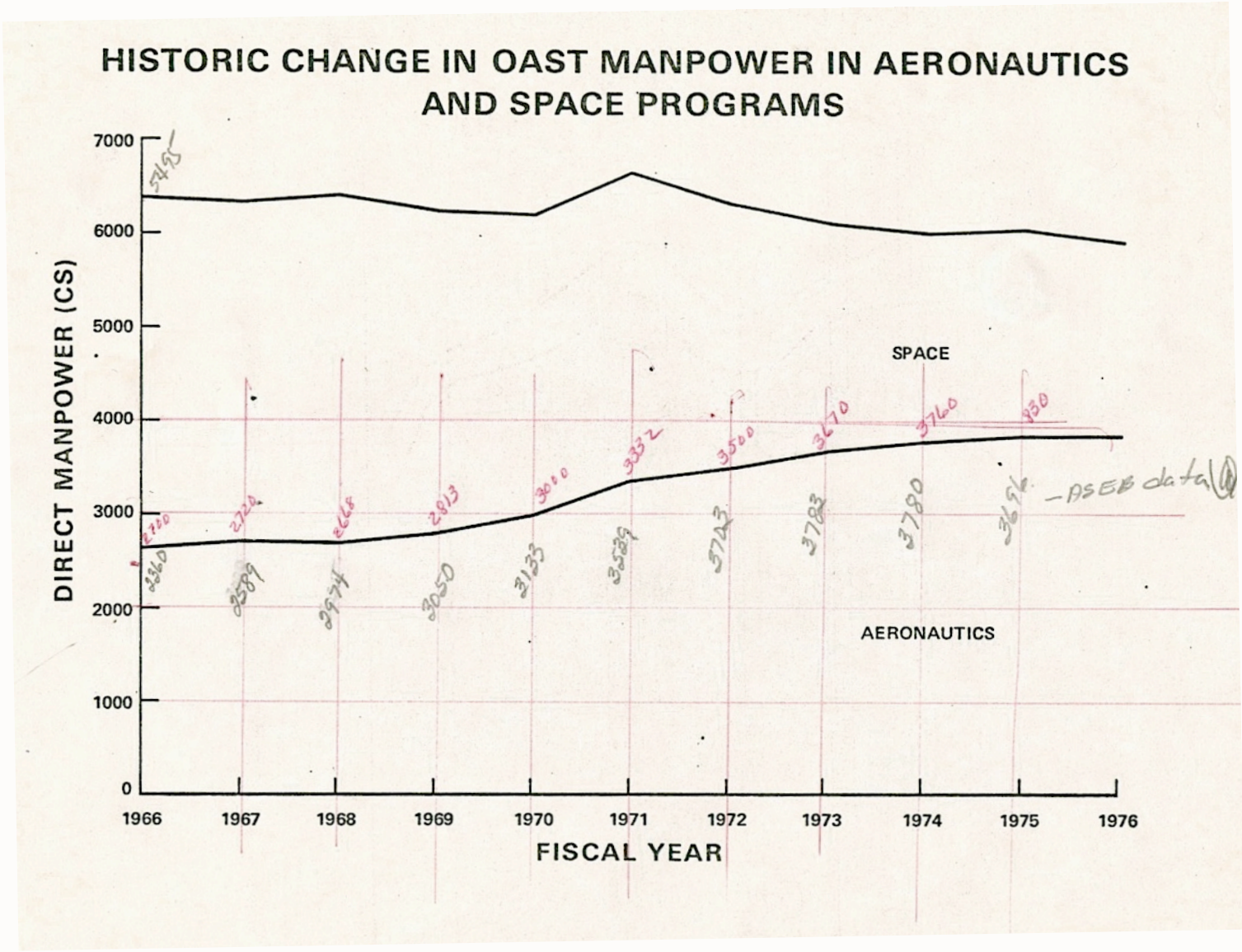
NASA OART/OAST

Personnel Comparison 2: CS Personnel Levels



NASA OART/OAST

Personnel Comparison 1: Aero vs. Space



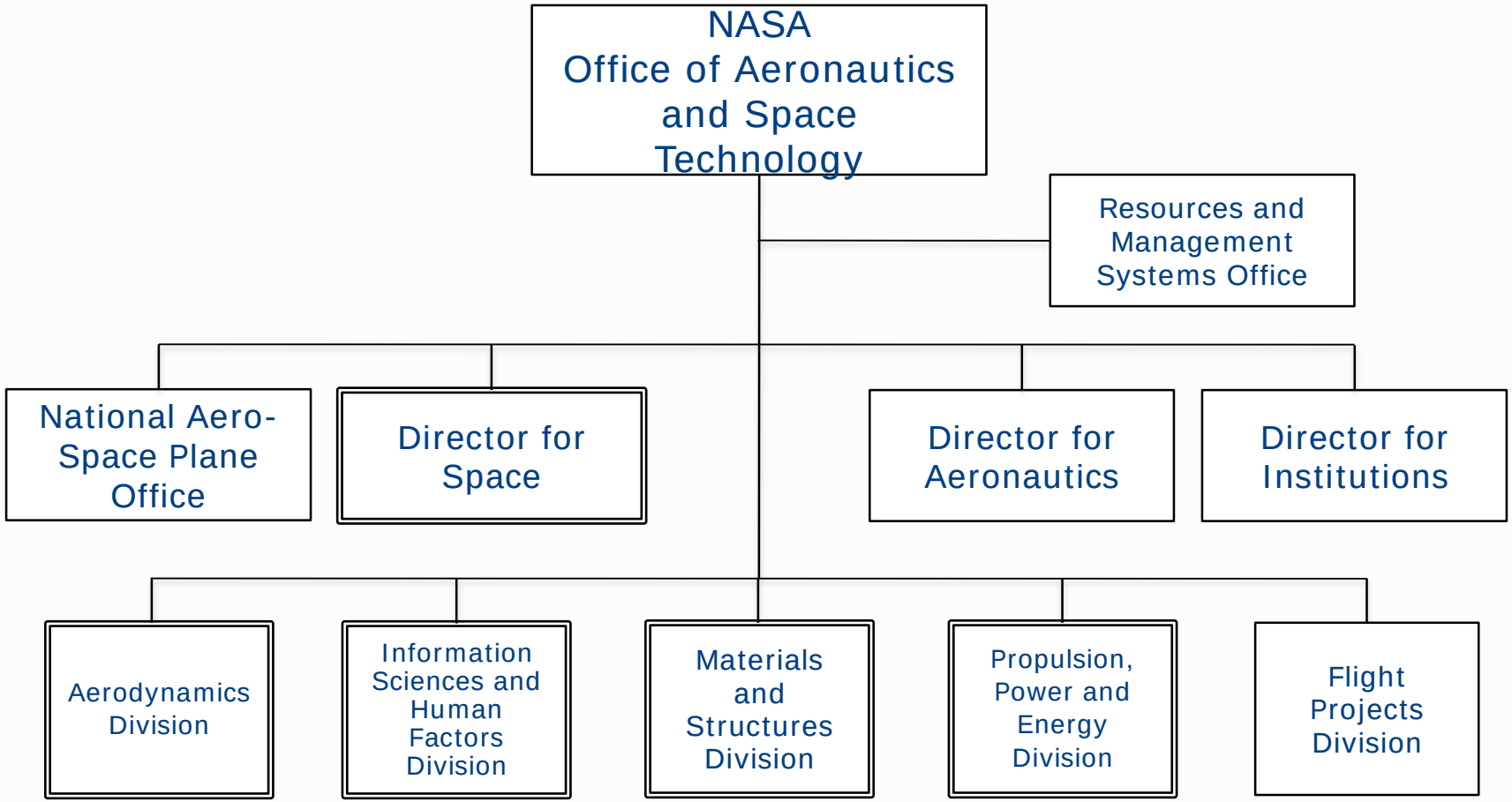
Summary: OART in the Context of NASA Space Technology R&D (’66-’73)

- From the earliest years of NASA, OART was not the sole organization with responsibility for advanced technology R&D
- However, in the 1960s, OART was by far the dominant player in a dynamic environment
  - TOTAL R&D budgets were ~ 11 % of NASA’s total
  - OART Percentage Share of Space Technology was about 51% of NASA total
  - While, when including Aeronautics R&D OART represented some 60% of NASA R&D
- By the early 1970s, this situation had changed…
  - TOTAL R&D budgets were up to ~ 15% of NASA’s total (while the overall budget had dropped by more than 1/2)
  - However, by 1973 OART’s share of Space Technology had dropped to only ~23% of NASA’s total
  - While, including Aeronautics R&D OART share had actually grown--and represented some ~66% of NASA’s total R&D investments

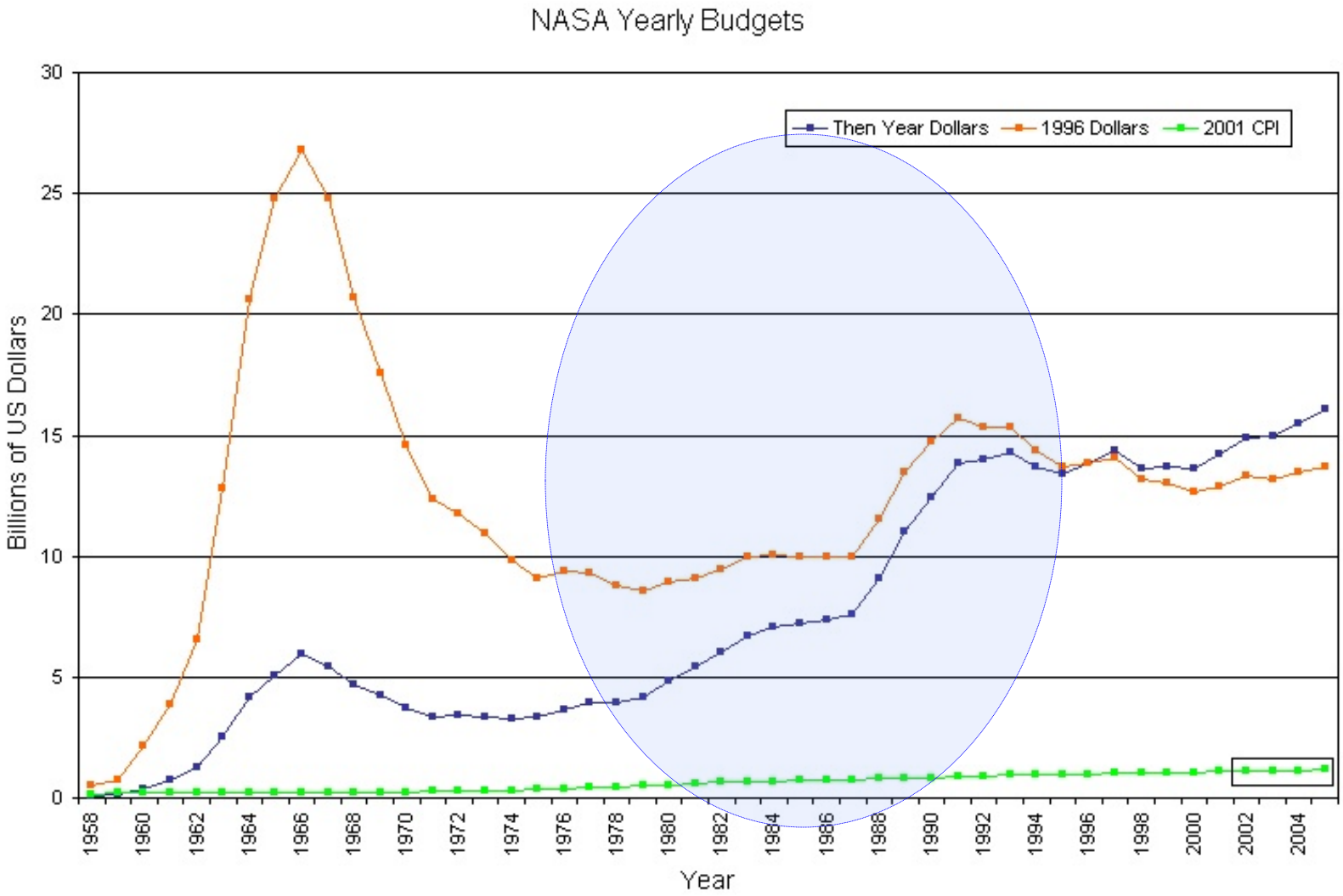
Fast Forward: the 1970s-1980s

- During the 1970s-1980s, OAST (formerly OART) made significant contributions in space technology for NASA's two major programs, as well as a range of developments support space and Earth science missions
  - The Space Shuttle
  - The Space Station
- During these years, the organization continued to play a supporting – rather than and enabling – role
- OAST returned to the tradition "NACA Model" organization
- As NASA budgets rose, so did those of OAST
  - Particularly after the low of Challenger

NASA OAST (c. 1989)

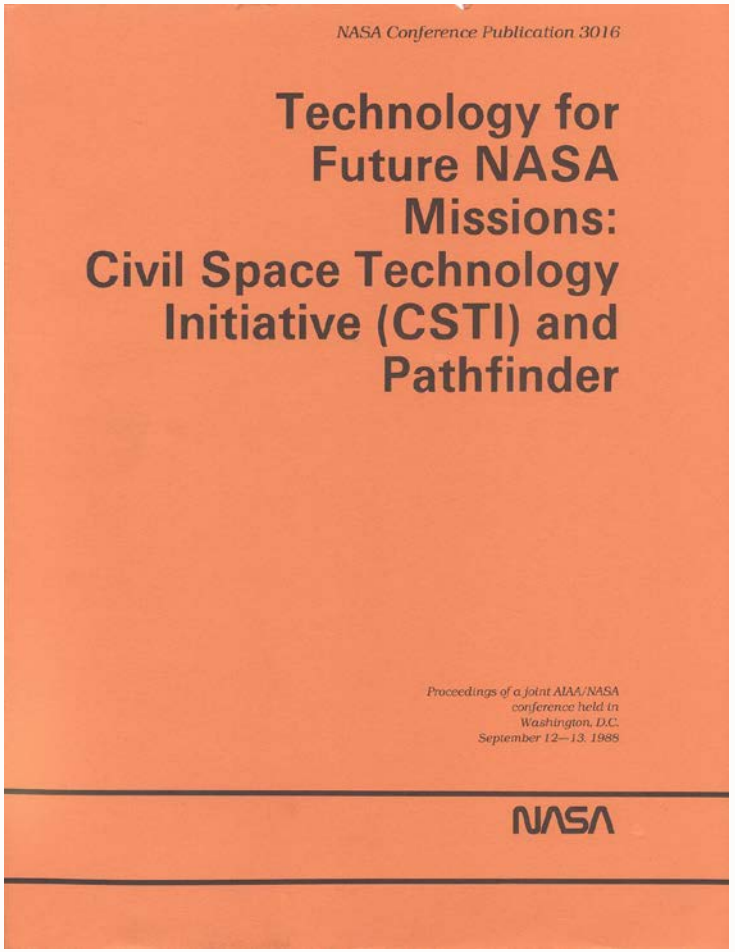


NASA Budget Overview 1958-2005
Rising Tides

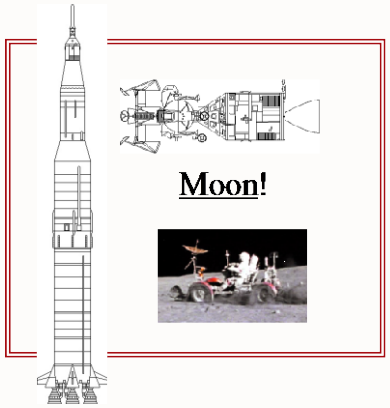


1988 & 1989
Civil Space Technology Initiative & Project Pathfinder

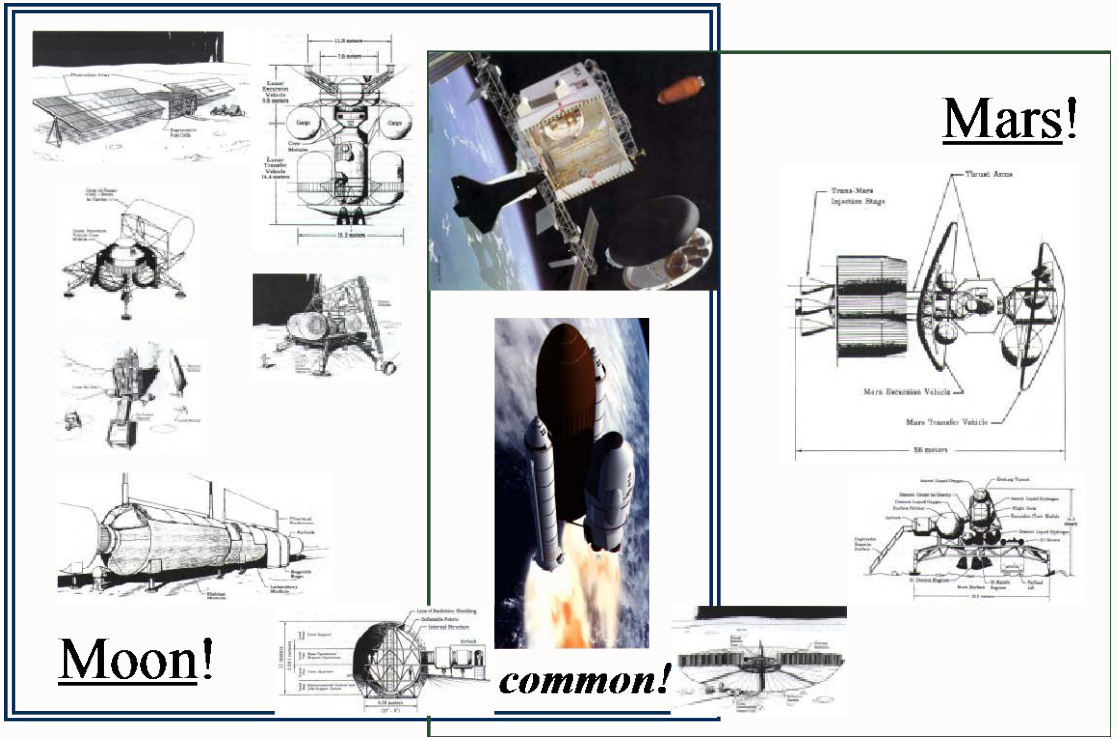
- Following the Challenger Disaster in Winter 1986, the reorganized OART / OAST was well-positioned to make the case that NASA and the US needed to replenish the "space technology base" for the civil space program
- The result was two new programs: CSTI in FY 1988, and Project Pathfinder in FY 1989



The Space Exploration Initiative 1989-1990

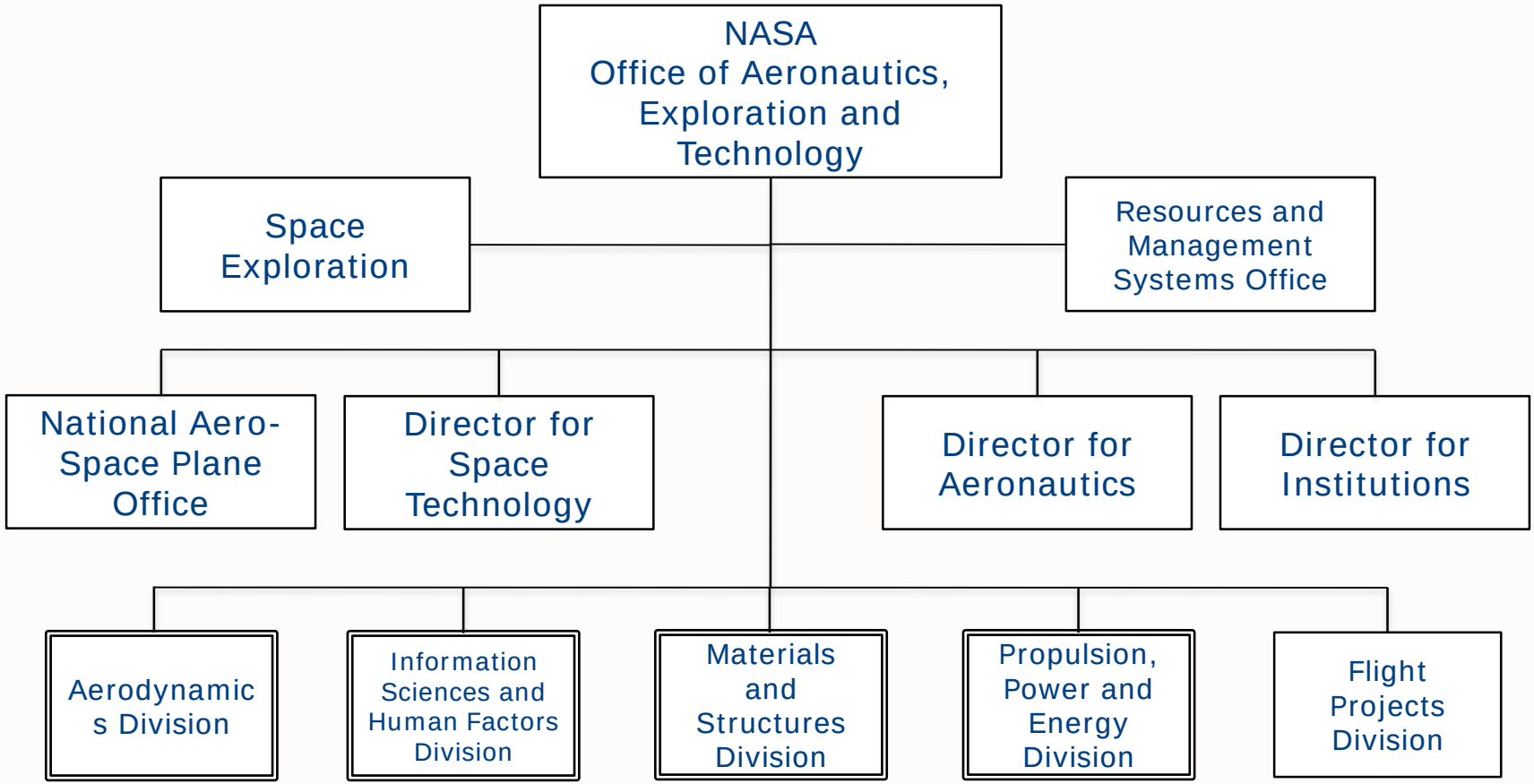


1960s APOLLO



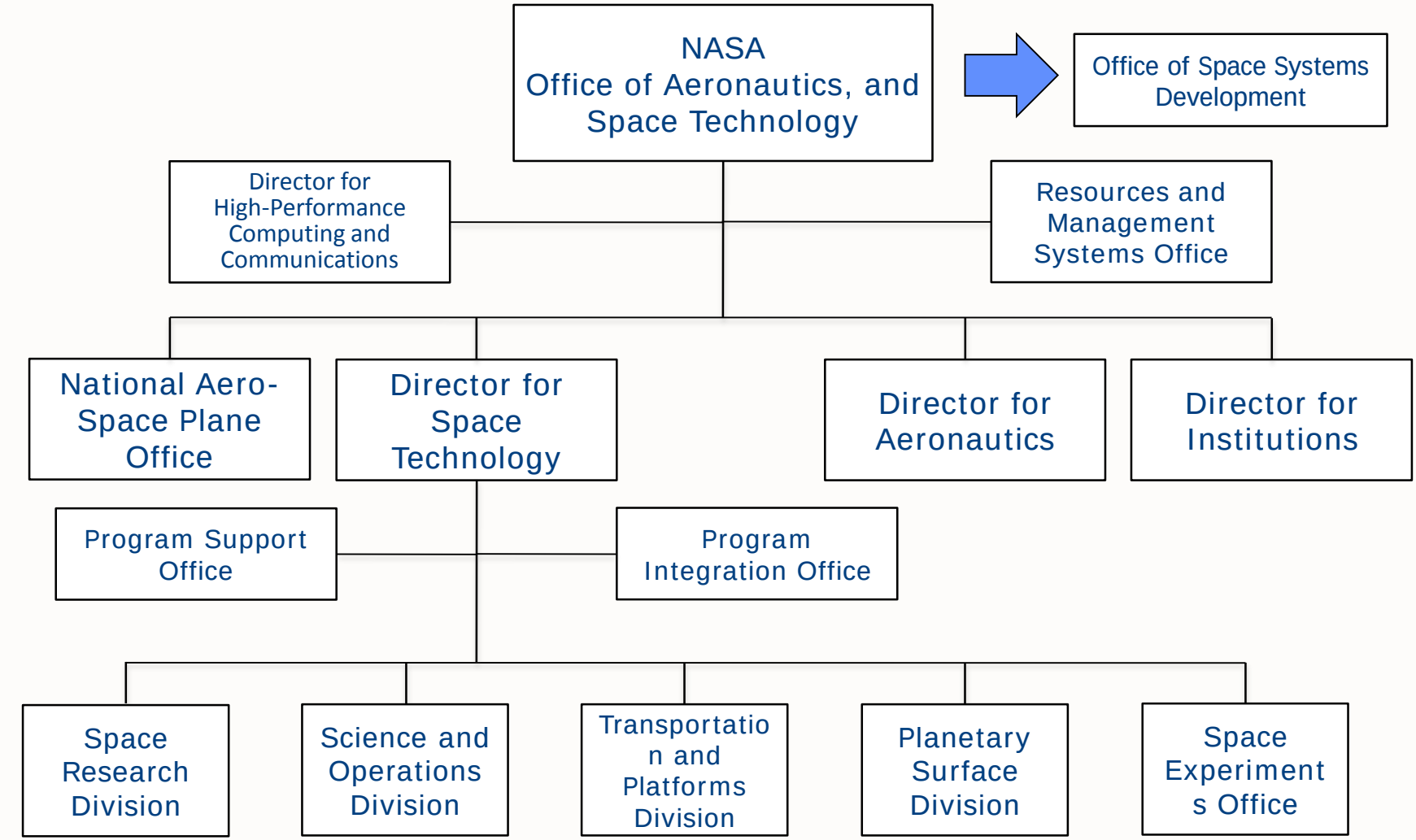
And ... a very different view of the role of technology

Changes to OAST (1 of 2): January 1991

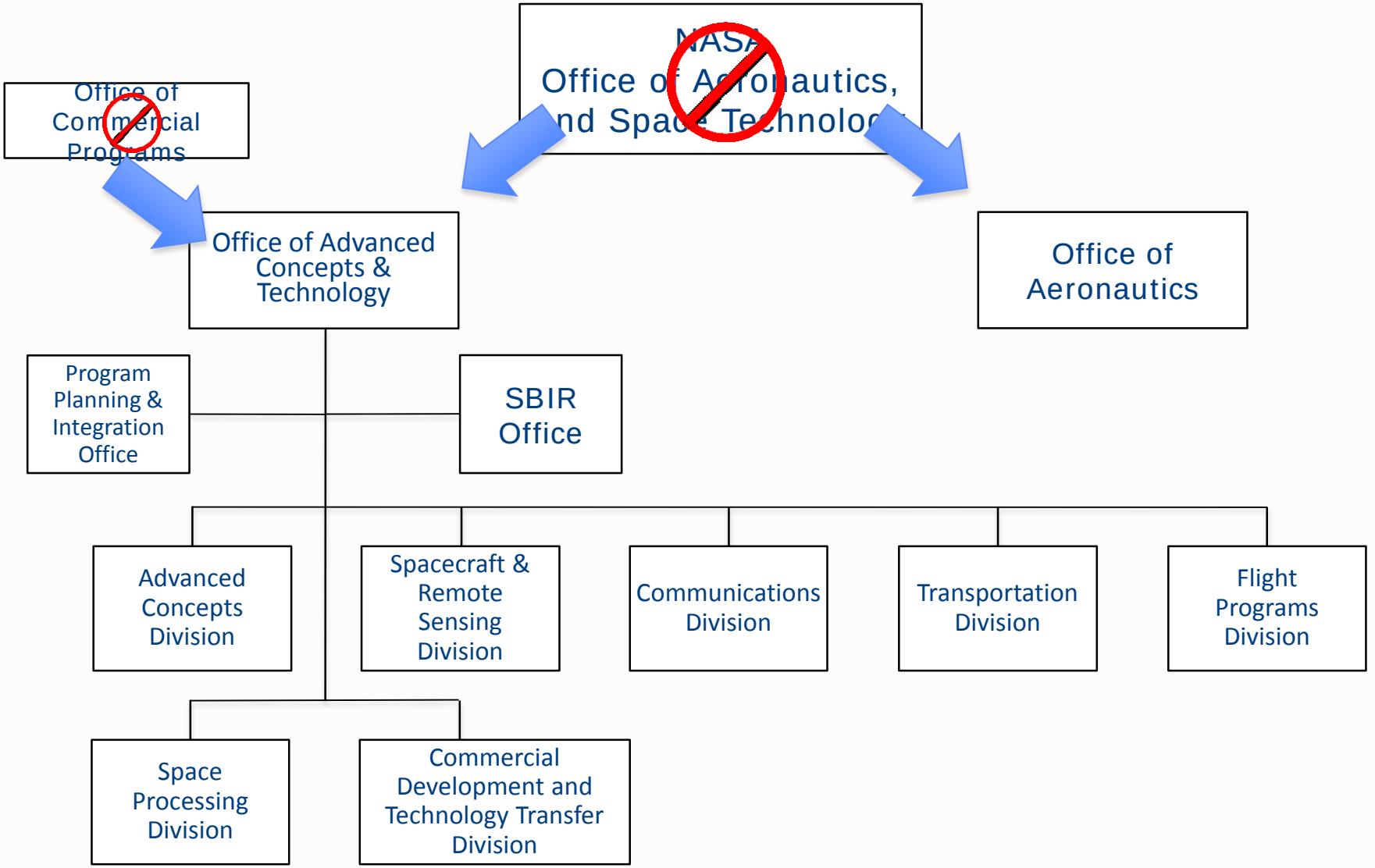


OAST Space R&T Budget in 1991 ~ $500M (2011, $)

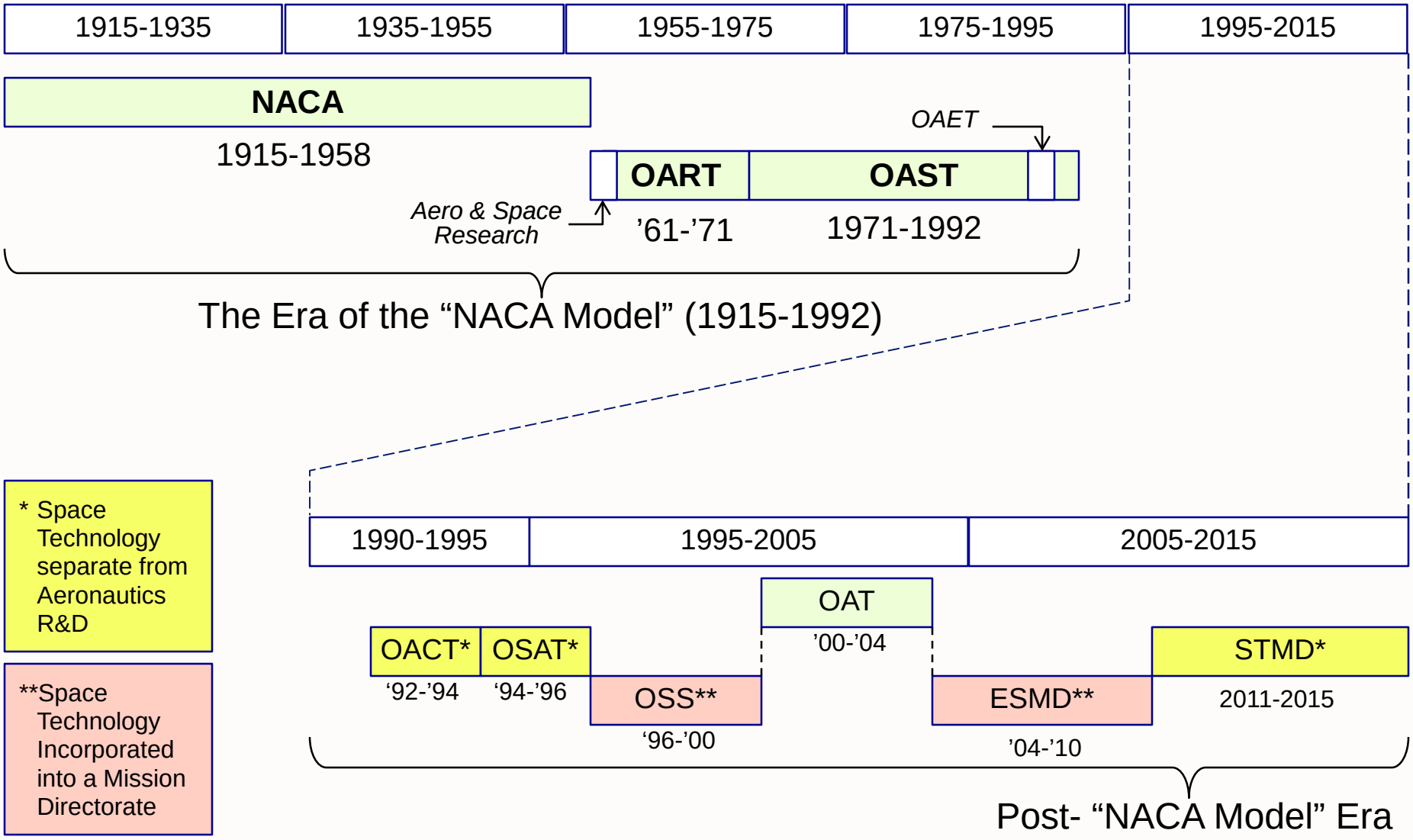
Changes to OAST (2 of 2): March 1992



The End of OART / OAST: 1993



An Integrated Timeline of NACA/OART/OAST
100 Years at a Glance



Program Budget Structures Comparison (1 of 2)
During the Era of the "NACA Model"- c. 1969

- The budget structures for space and aeronautics in the late 1960s, followed a largely discipline-based organization
- Following principles derived from those of the NACA era

Space Technology Program

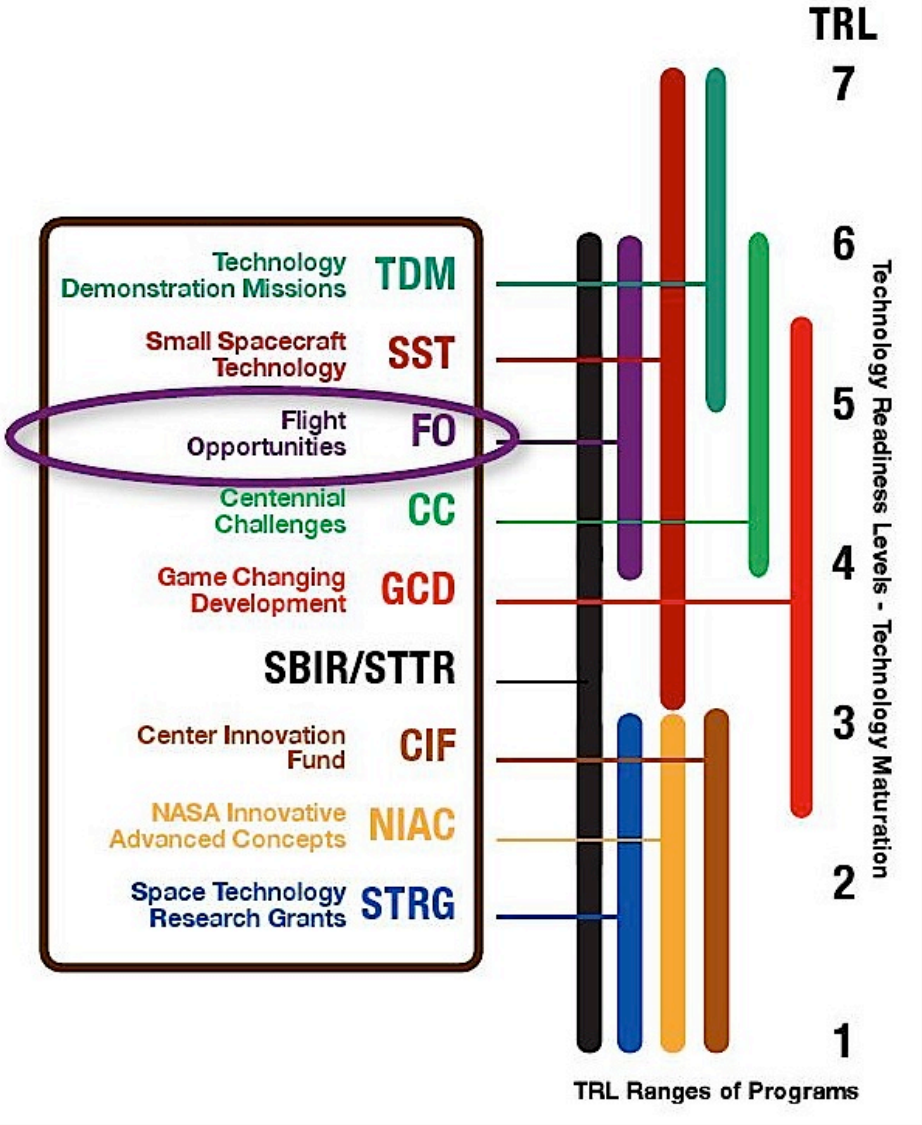
Basic Research
Space Vehicle Systems
Electronics Systems
Human Factor Systems
Chemical Propulsion
Space Power and Electric Propulsion Systems
Nuclear Rockets

Aeronautical Vehicles Program

Aircraft Aerodynamics
Aircraft Loads and Structures
Air Breathing Propulsion
Aircraft Operating Environment
Aircraft Flight Dynamics
Aircraft Support
Supporting Research Activities
General Aviation, V/STOL, Subsonic, Supersonic, Hypersonic

Program Budget Structures Comparison (2 of 2)
After the Era of the "NACA Model"

- The structure has changed several times over the past 20 years…
- For example, in 2015 NASA Space Technology program budget are structured according to programmatic objectives, largely in terms of
  - A planned progression through various stages of technology maturity
  - Specific program set asides
  - A targeted investment related to a particular type of spacecraft (small spacecraft)



Closing Observations (1 of 3)

- At the founding of NASA, advanced space technology research and development represented one of the central features of the new organization
- OART (the Office of Advanced Research and Technology), formed a couple of years after the founding of NASA, at NASA Headquarters Washington, DC represented
  - The principal successor of the former NACA headquarters
  - The focal point for the former NACA Field Centers
- The purposes of the new Office were driven by new space objectives, rather than legacy aeronautics objectives
  - Aeronautics technology R&D became for the 1960s a minor aspect of the overall OART program
- The culture – organization and programs – however, remained that of NACA – discipline oriented with selected systems-focused projects

Closing Observations (2 of 3)

- A direct successor of NASA's predecessor NACA, OART was a central organizational element of US Space Agency from its creation in 1958
- OART's mission radically changed at the end of the Apollo era from space research and technology to primarily aeronautics research and technology – as was reflected in a new name for the organization: OAST
- Despite ongoing changes and budget challenges during the 1970s, OART / OAST continued to make strong contributions to the NASA space, and US civil space technology foundation
- For several years during the later 1980s, OART/OAST was on the verge of restoring its prior role as a principal wellspring of new space – then the organization was suddenly dissolved in the early 1990s, after more than 30 years of existence
- Following the formation of NASA, the remaining "heart" of the NACA within OART (later OAST) often embodied the key elements of the "NACA Model"

The “NACA Model” vis-à-vis Innovation in Space Technology

Characteristics

- Purpose
- Organization
- Budgets
- Expertise

The “NACA Model” vis-à-vis Innovation in Space Technology

Characteristics

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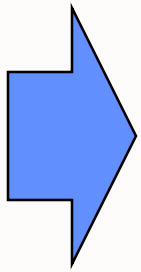

Results

- Agility
- Robustness
- Leadership
- Accomplishment