

From Von Karman to Commercial Space

Aerojet's Contribution to Propulsion 1942 – 2010

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Propulsion Consultant**

**International Symposium
Personal and Commercial Spaceflight
Las Cruces, NM**

October, 2010

From Von Karman to Commercial Space – 68 Years

AEROJET

- **Humble Beginnings**
- **Expanding a New Industry**
- **How it Was**
- **Looking Ahead / Commercial Programs**

The Start of a Success Story

AEROJET



Dr. Frank Malina



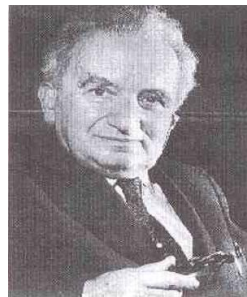
John Parsons



Dr. Martin Summerfield



Ed Forman



Dr. Theodore Von Karman

Founded on March 20, 1942, these men incorporated AEROJET ENGINEERING CORPORATION with \$250 each for a total of \$1250.

Expanding a New Industry – Major Flight Programs

AEROJET

1942

Formative Years

△ Von Karman / Aerojet Start

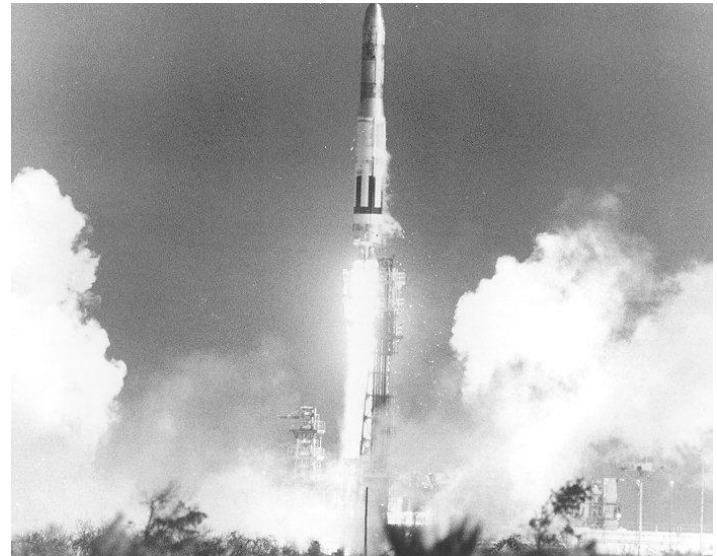
- JATO
- Aerobee
- Nike
- Thor
- Able

1955

Expanding Years

△ Titan I Contract

- Titan II / III
- Minuteman
- Polaris
- Peacekeeper
- Vanguard



First Titan Launch (February 1959)

1963

Declining Years

△ Gemini (1965) (first manned flight)

- Delta II
- Apollo SPS (1968)
- Titan III / IV
- Shuttle OMS (1981)
- Atlas SRM

Propulsion Personnel

5

1,500

5,000

11,000

22,000

7,000

3,000

Today

Expanding a New Industry – How it Was – Titan I

AEROJET

The Challenge

- Limited Staff
- Limited Experience
- No Major Facilities
- No Modern “Tools”
- Limited Data Base
- Limited Suppliers

The “Environment”

- National Commitment
- Schedule Urgency
- Unlimited Budget
- Minimum Oversight
- Delegated Decisions
- Test-Fail-Fix Approach
























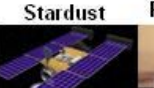



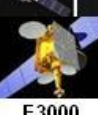

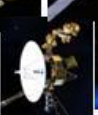









And

High Risk Tolerance

49 Months to First Flight

Propulsion Products and Experience for Commercial Space



<p style="text-align: center;">Spacelift</p> <ul style="list-style-type: none"> • First stage and upper stage liquid engines • Solid rocket motor boosters 	<div style="display: flex; justify-content: space-around; text-align: center;"> <div style="text-align: center;">Titan I </div> <div style="text-align: center;">Titan II </div> <div style="text-align: center;">Gemini </div> <div style="text-align: center;">Titan 23G </div> <div style="text-align: center;">Titan III/IV </div> <div style="text-align: center;">Delta II </div> <div style="text-align: center;">Atlas V </div> <div style="text-align: center;">Taurus II </div> </div>
<p style="text-align: center;">Orbital Maneuvering and Transfer</p> <ul style="list-style-type: none"> • Monoprop and biprop reaction control thrusters • Monoprop gas generators 	<div style="display: flex; justify-content: space-around; text-align: center;"> <div style="text-align: center;">Mercury </div> <div style="text-align: center;">Apollo </div> <div style="text-align: center;">Orion </div> <div style="text-align: center;">ATV </div> <div style="text-align: center;">Cygnus </div> </div> <div style="display: flex; justify-content: space-around; text-align: center; margin-top: 10px;"> <div style="text-align: center;">Gemini </div> <div style="text-align: center;">Space Shuttle </div> <div style="text-align: center;">X-38 </div> <div style="text-align: center;">HTV </div> </div>
<p style="text-align: center;">Satellites and Deep Space</p> <ul style="list-style-type: none"> • Monoprop thrusters and systems • Biprop thrusters and systems • Pulsed plasma, arcjet, ion, and Hall Effect thrusters 	<div style="display: flex; justify-content: space-around; text-align: center;"> <div style="text-align: center;">BSS 602 & 702B </div> <div style="text-align: center;">SSL1300 </div> <div style="text-align: center;">Star-2 </div> <div style="text-align: center;">MESSENGER </div> <div style="text-align: center;">Cassini </div> <div style="text-align: center;">Mars Pathfinder </div> <div style="text-align: center;">Stardust </div> <div style="text-align: center;">Mars Phoenix </div> <div style="text-align: center;">Mars Odyssey </div> </div> <div style="display: flex; justify-content: space-around; text-align: center; margin-top: 10px;"> <div style="text-align: center;">A2100™ </div> <div style="text-align: center;">E3000 </div> <div style="text-align: center;">NEAR </div> <div style="text-align: center;">Voyager </div> <div style="text-align: center;">Lunar Prospector </div> <div style="text-align: center;">Genesis </div> <div style="text-align: center;">Deep Impact </div> </div>
<p style="text-align: center;">Auxiliary Propulsion</p> <ul style="list-style-type: none"> • Reaction control monoprop thrusters • Stage separation solid motors • Monoprop attitude and reaction control systems 	<div style="display: flex; justify-content: space-around; text-align: center;"> <div style="text-align: center;">Ares I </div> <div style="text-align: center;">Delta II </div> <div style="text-align: center;">Atlas V </div> <div style="text-align: center;">Delta IV </div> <div style="text-align: center;">Pegasus </div> <div style="text-align: center;">Athena </div> </div>

Proven Products Leveraged For Commercial Space

AEROJET

Product Heritage

- Apollo SPS (R-4D)
- Titan II (LR87 / LR91)
- Shuttle (Primary RCS)
- Peacekeeper (SR119)

Other Programs

- Russian N-1 (NK 33)

Commercial Beneficiary

- Boeing 602 Satellites (HiPAT)
- European ATV (R-4D)
- Japanese HTV (R-4D)
- Titan 23G (LR87 / LR91)
- Kistler (LOX/Ethanol OME)
- Minotaur IV / V (SR119)
- Taurus II (AJ26)

Commercial Programs – Active and Potential

AEROJET

Current

- Taurus II
- Cygnus
- Sundancer
- Dreamchaser
- Delta II
- Commercial Satellites
- Japanese ATV
- European HTV
- Other -- Proprietary

Future

- Bigelow BA330
- Commercial Crew
- Launcher One
- Others -- Proprietary

Aerojet Positioned to Respond to Market Needs

Thanks, Founders, For Your Vision

AEROJET

Then

Now



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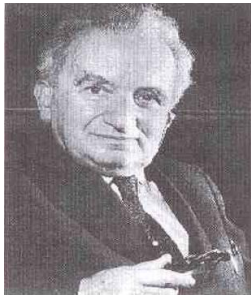
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Over 3,000 people located in 13 states with \$795M in Sales in 2009. GENCORP AEROJET specializes in Space Launch Systems, Tactical Systems, Missile Defense Systems, and Force Projection and Protection