

# REPORT DOCUMENTATION PAGE

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Unclassified	Unclassified	Unclassified	A		<b>19b. TELEPHONE NUMBER (include area code)</b> (661) 275-5015

2 items enclosed = 210 + 213

⊕ Paper Rec'd After 30-day Deadline = { 22 days until Deadline }  
FILE

MEMORANDUM FOR PRS (In-House Publication)

FROM: PROI (STINFO)

03 Sept 2002

SUBJECT: Authorization for Release of Technical Information, Control Number: **AFRL-PR-ED-VG-2002-213**  
Shawn Phillips (PRSM), "AFRL POSS Applications Research" (viewgraphs)

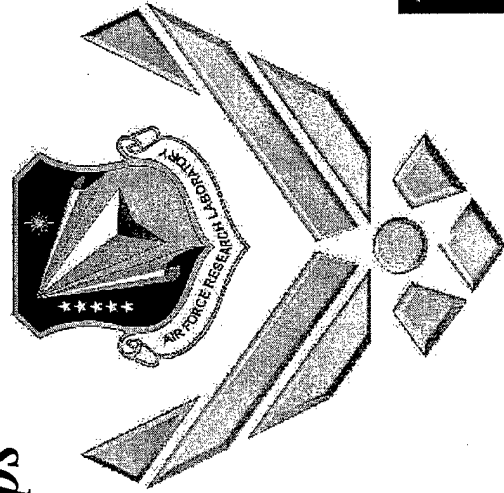
**POSS Nanotechnology Conference**  
**(Huntington Beach, CA, 25-27 September 2002) (Deadline: 25 Sept 02)**

(Statement A)

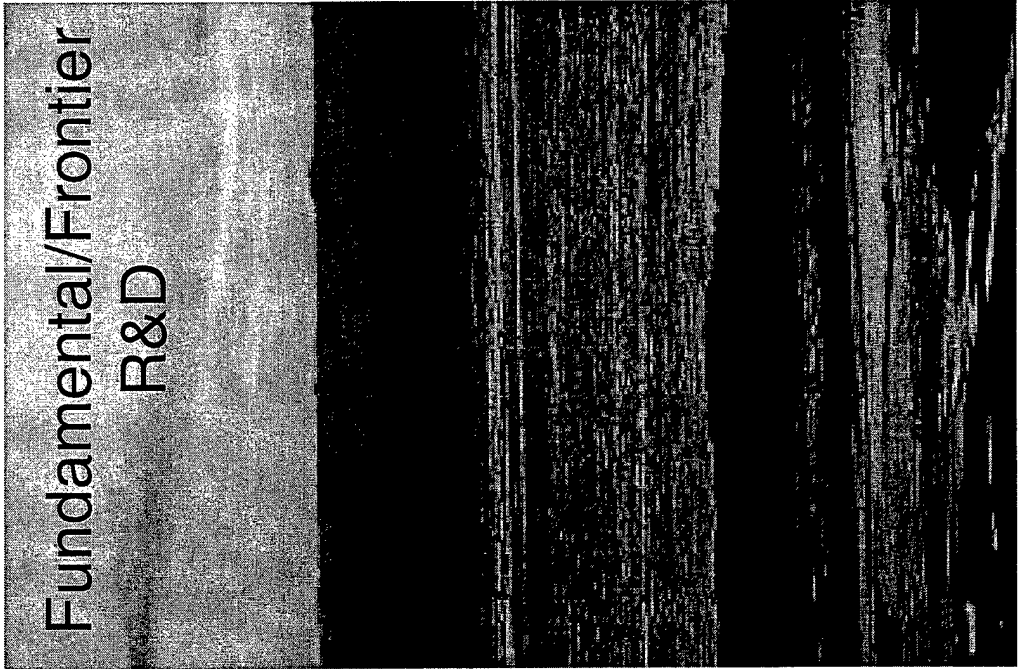
**AFRL POSS<sup>®</sup>**

***Applications Research***

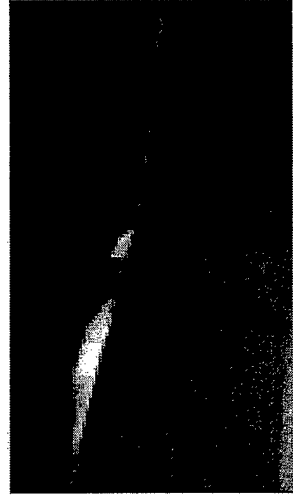
*Dr. Shawn Phillips*



Fundamental/Frontier  
R&D

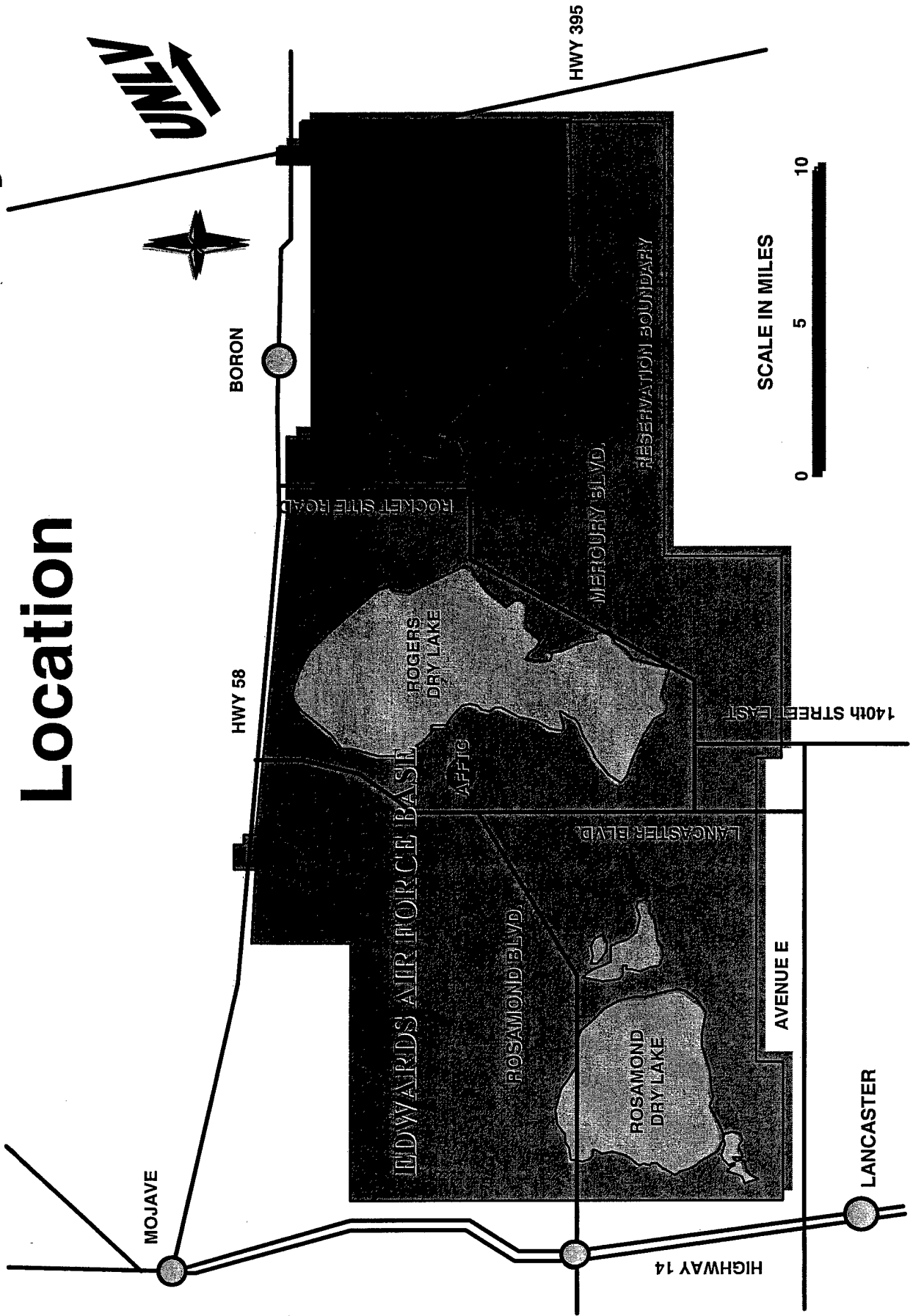


Applications  
R&D



Technology  
Transfer/Transition

# Air Force Research Laboratory Location

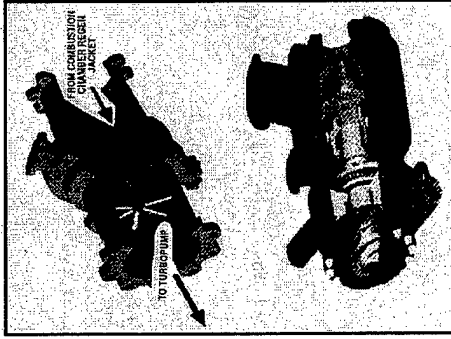


# Air Force Research Laboratory Edwards AFB / Propulsion Directorate

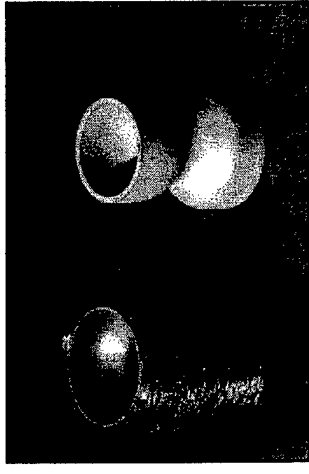
## MISSION STATEMENT

Create and Transition  
Propulsion and Power  
Technology for Military  
Dominance of Air and Space

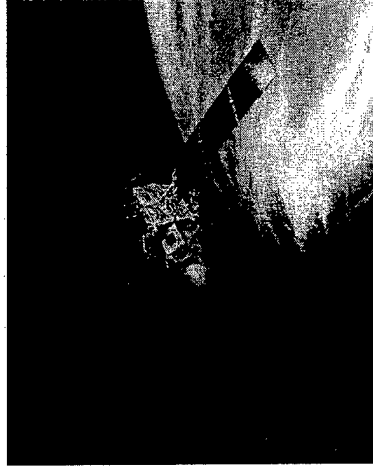
(IHPRPT 2x)



IPD



CARBON / CARBON



ESEX

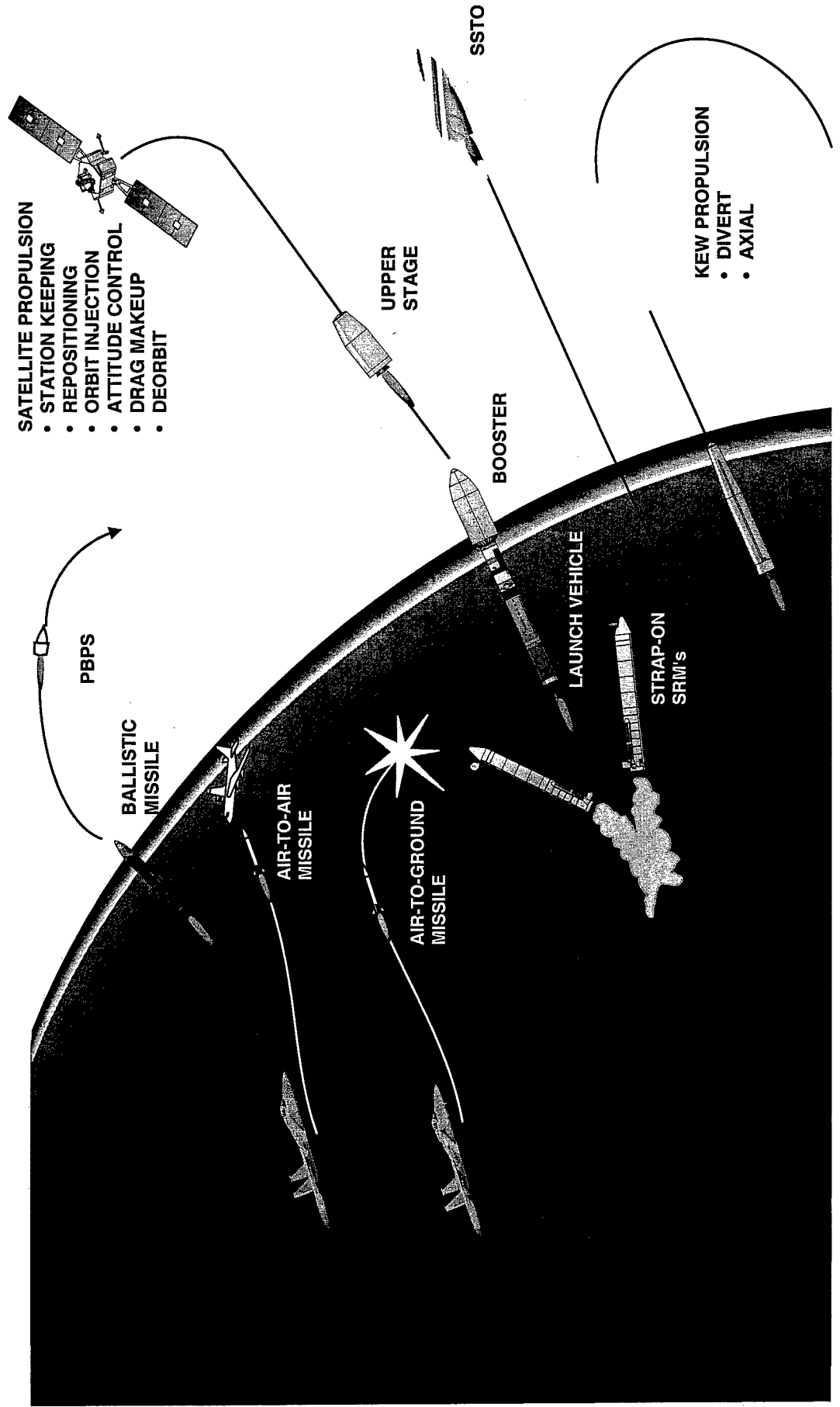


OTV



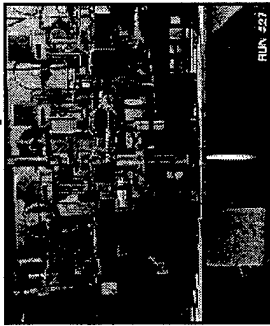
HEDM

# Rocket Propulsion Technology Fundamental to all Space & Missile Systems



# Edwards Research Site Propulsion Directorate

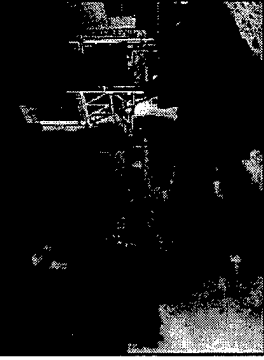
Satellite Propulsion



Experimental Systems



Large Systems Complex



Small Solid Components

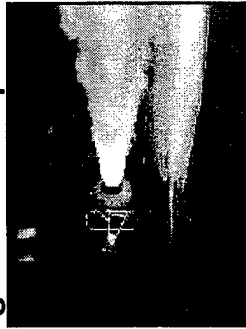


TO 10,000,000 LB THRUST  
FIXED OR SPUN  
HORIZONTAL OR VERTICAL  
ORIENTATION  
ENVIRONMENTAL CONDITIONING  
HIGH HAZARD

VEHICLE FLIGHT/HOVER TESTING  
REDUCED SMOKE PROPULSION STUDIES

SOLAR THRUSTER EXPERIMENTS  
SATELLITE g LOAD STUDIES  
TETHERED LAUNCH CAPABILITY

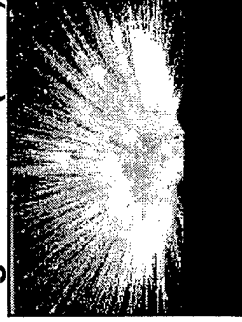
Large Solid Components



High Thrust (Solid and Liquid)



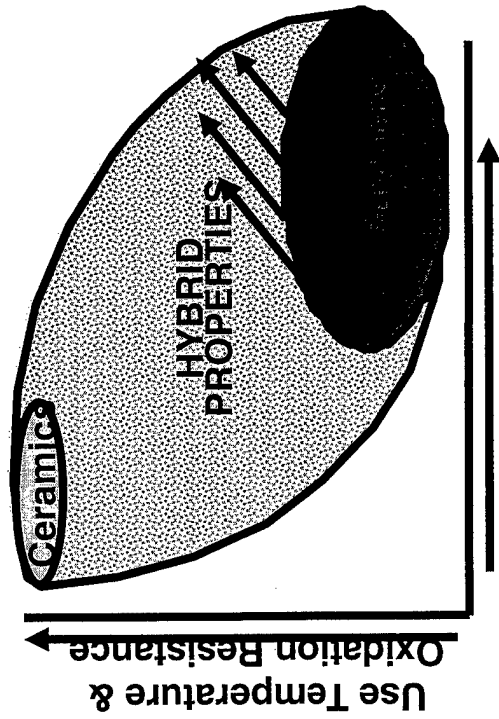
High Hazard (Solid)



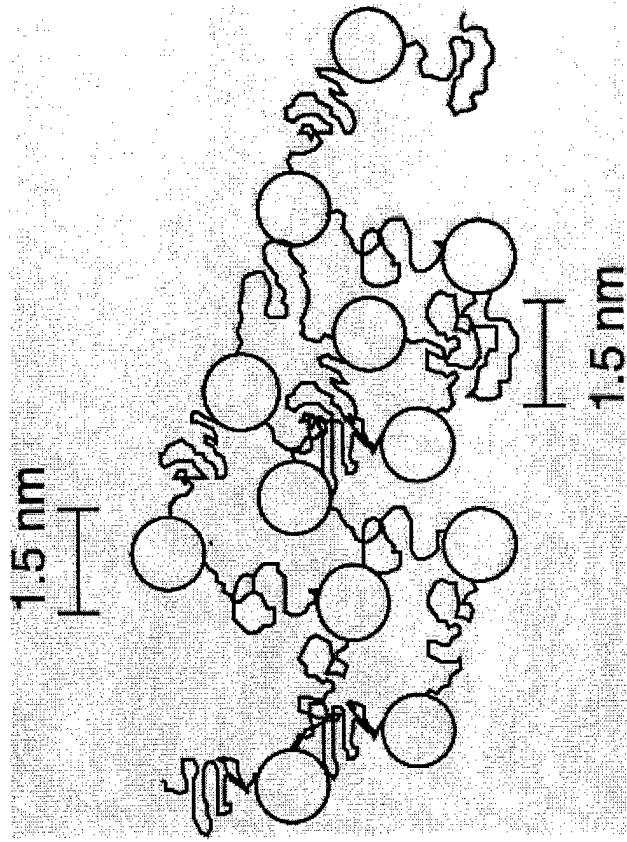
Large Liquid Components

# Key Aspects of POSS™ Technology

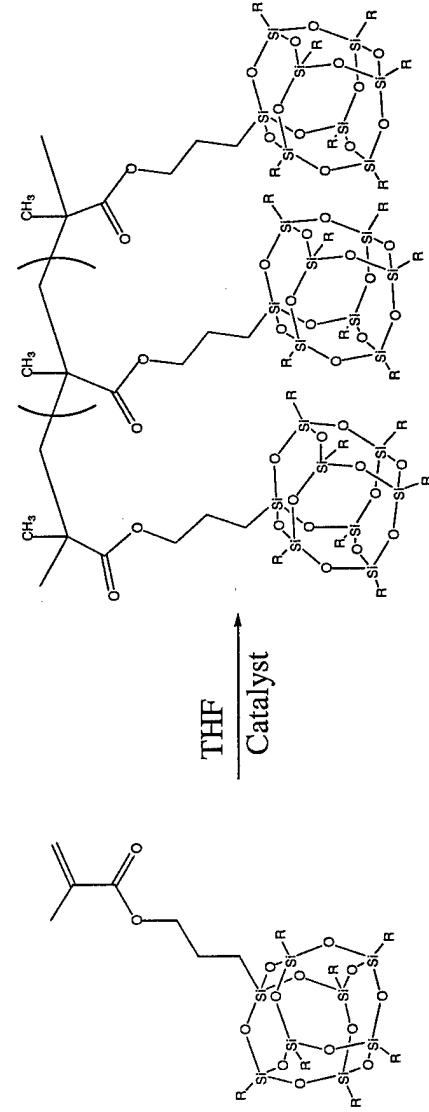
Hybrid (inorganic/organic) Composition



Nanostructured™ Chemical Reinforcement



Toughness, Lightweight & Ease of Processing



POSS™ technology does not require manufacturers to retool or alter existing processes.

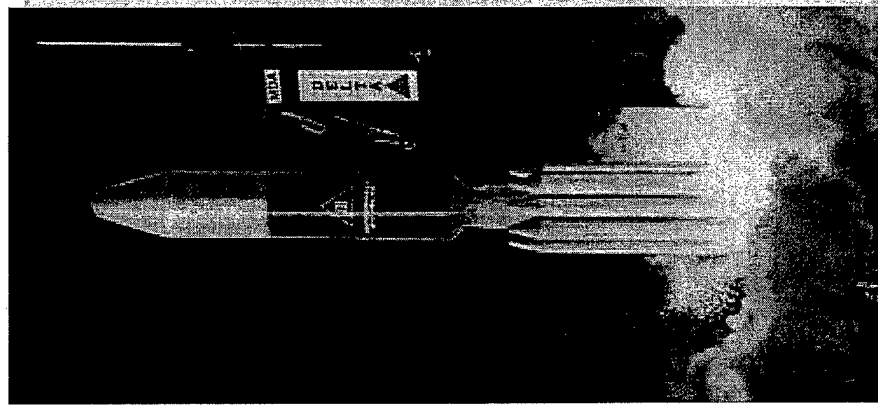
Lichtenhan et. al. *Macromolecules* **1993**, 26, 2141.  
Lichtenhan, *Polym. Mater. Encyclopedia* **1996**, 10, 7768.

# POSS<sup>®</sup> for Propulsion & Beyond

## High-Performance Nanostructured Polymers

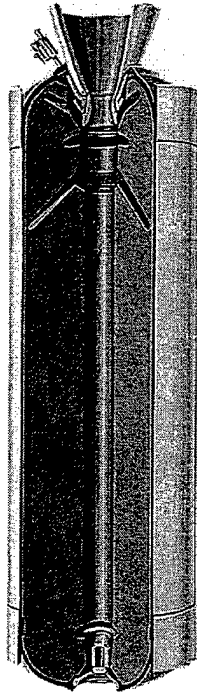
- High temperature case and motor insulation for solid rockets
- Plastic tubing and ducting for liquid rockets engines
- Space-survivable materials and coatings
- High-temperature canopies and hybrid lubricants

**POSS Nanotechnology Offers Versatility!**

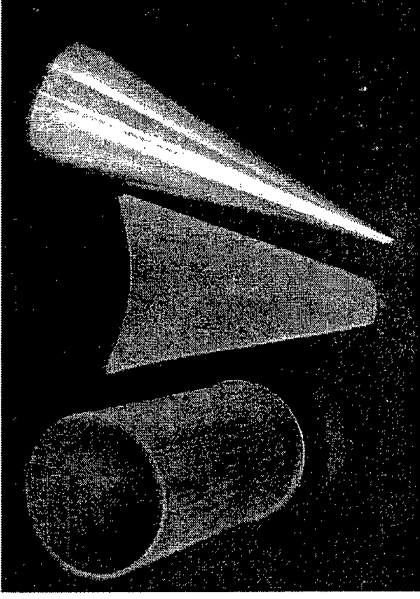


# Solid Rocket Motor Insulation Program

*Case Insulation*



*POSS-Insulation*

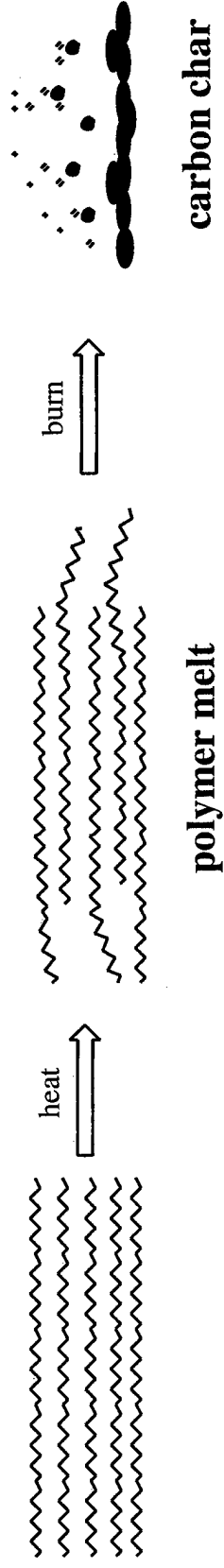


## Why POSS?

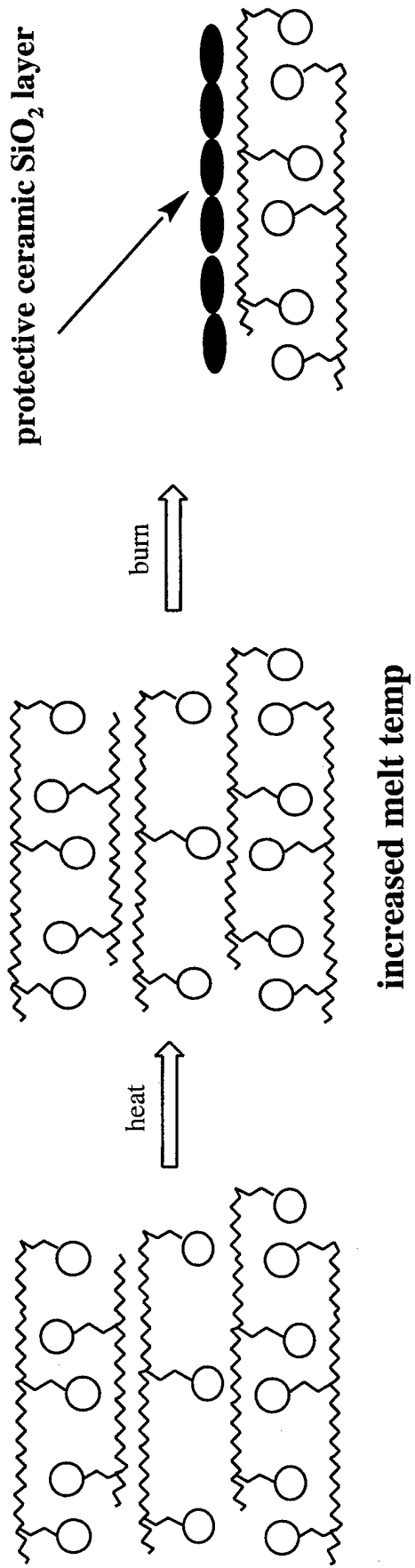
- need inorganic material with polymer flexibility
- ability to incorporate very high loadings
- processable using traditional equipment!!
- maintain mechanical property range
- physical cross-linker for TPEs

# POSS for Ablative Materials

## Traditional Polymer



## POSS Polymer



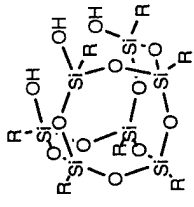
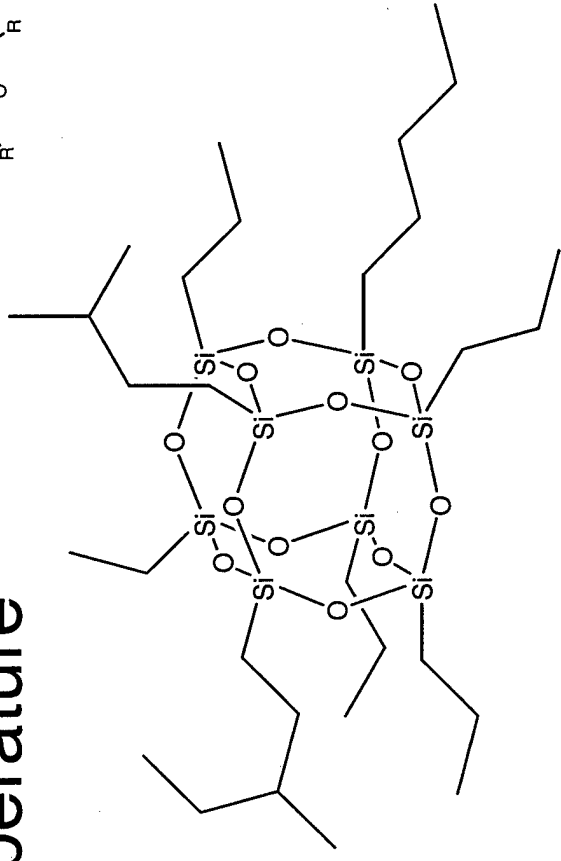
**The Silicon to Oxygen ratio of 1:1.5 may be the key!!!**



# POSS Materials for Aerospace

High Temperature

Hybrid Lubricant Applications

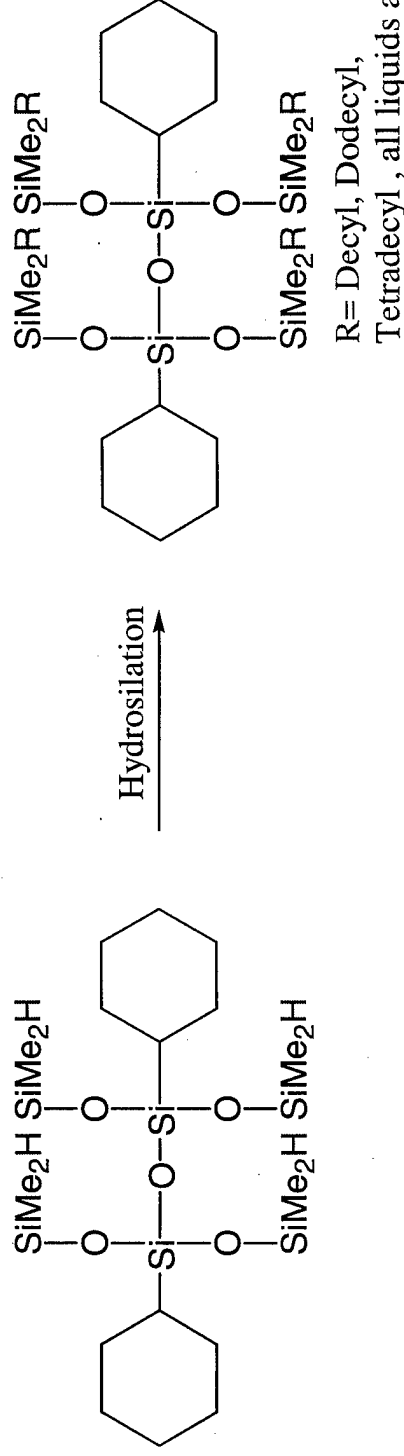


Why POSS?

- POSS based lubricants  $T_{dec} = 590\text{ }^{\circ}\text{F}$
- Cornucopia of monomers for compatibility and viscosity control

# Generation III Lubes

## CyT<sub>2</sub> Class



**When R=Decyl the viscosity at -40 °F is 4000 cP**

**When R=Dodecyl, the freezing point is 10 °F**

**Chemical and Physical Blending Studies Show that POSS follows the Rule of Mixtures**

**Joint Patent with Hybrid Plastics filed this year**

# Dual Use S&T: WMR

## Jet Canopies



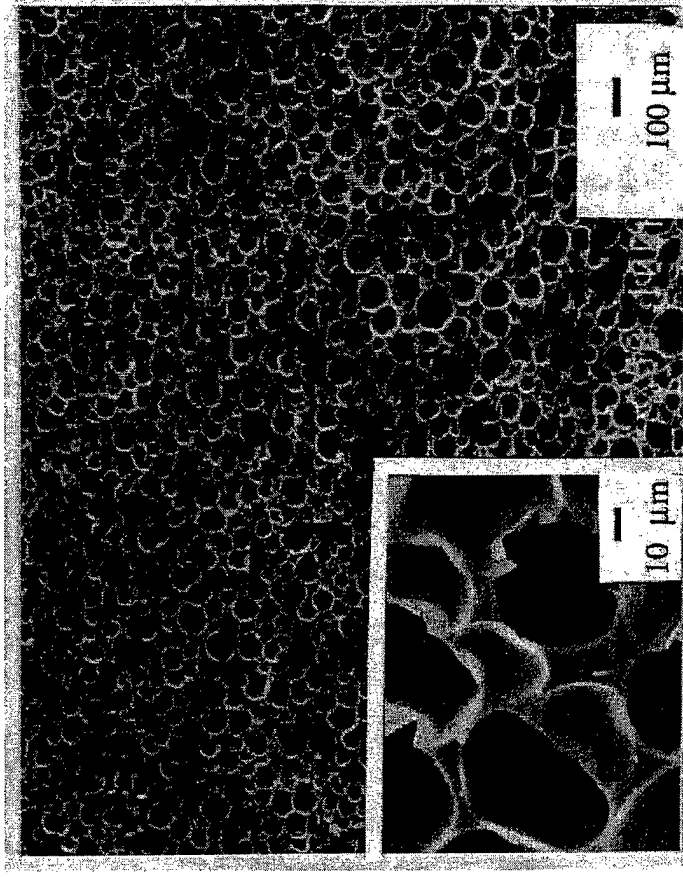
### POSS-based Transparent Materials

- Mach 2x speeds limited for plastic canopy (need increased HDT)
- Target Engagement Times can be reduced by increasing flight speed

### Why POSS?

POSS-PMMA increases use temp. up to 150 °C  
POSS can be optically transparent!!  
POSS-PMMA readily processed via foaming  
Ability to make POSS-polycarbonates also

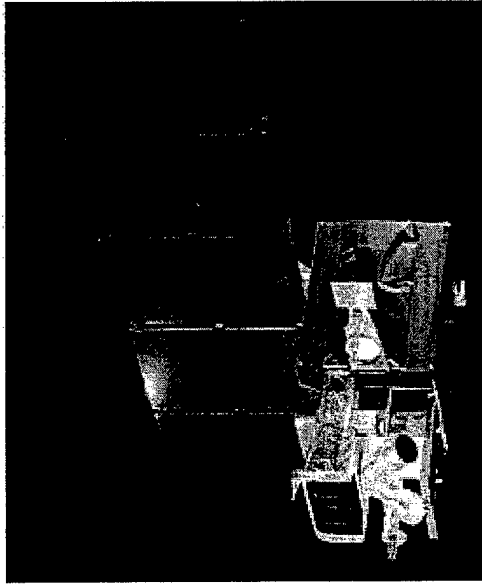
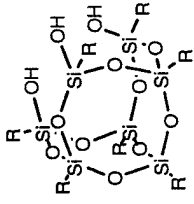
WMR's Current High Performance Foam



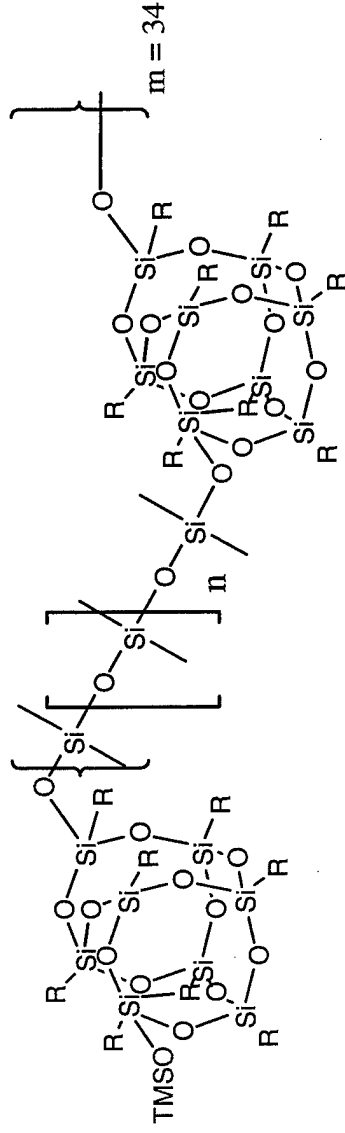
Cell Sizes can be Tailored  
From Nano To Several mm

# POSS Materials for Space

## Critical for Increasing Lifetime



Satellites & Space Systems



POSS-PDMS copolymers

### POSS Nanocomposite Payoffs

- Maximum Space Survivability
  - LEO, AO, VUV, Impact
- Lower Density 'Filler'
- High Modulus
- Resins for all Structural Applications

### Simulated 3 mo. AO/VUV Exposure

- 9-20x greater AO resistance than current state of art
- Even better AO/VUV resistance
- Current NASA, Aerospace Corp., and University collaborations

# Where Are We Now?

## Research:

New Monomers & Feedstocks (>180) - simplicity  
Control & Prediction of Property Enhancements

## Production:

Multi-Ton Production Capability!!

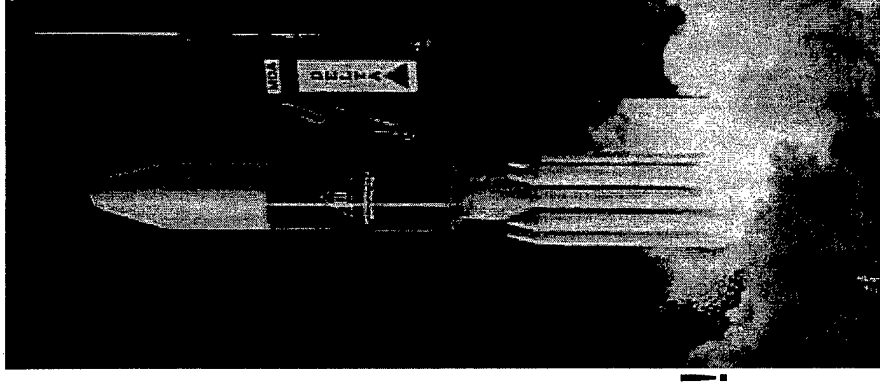
10-100x Reduction in Cost (monomer dependent)!!!

## Application:

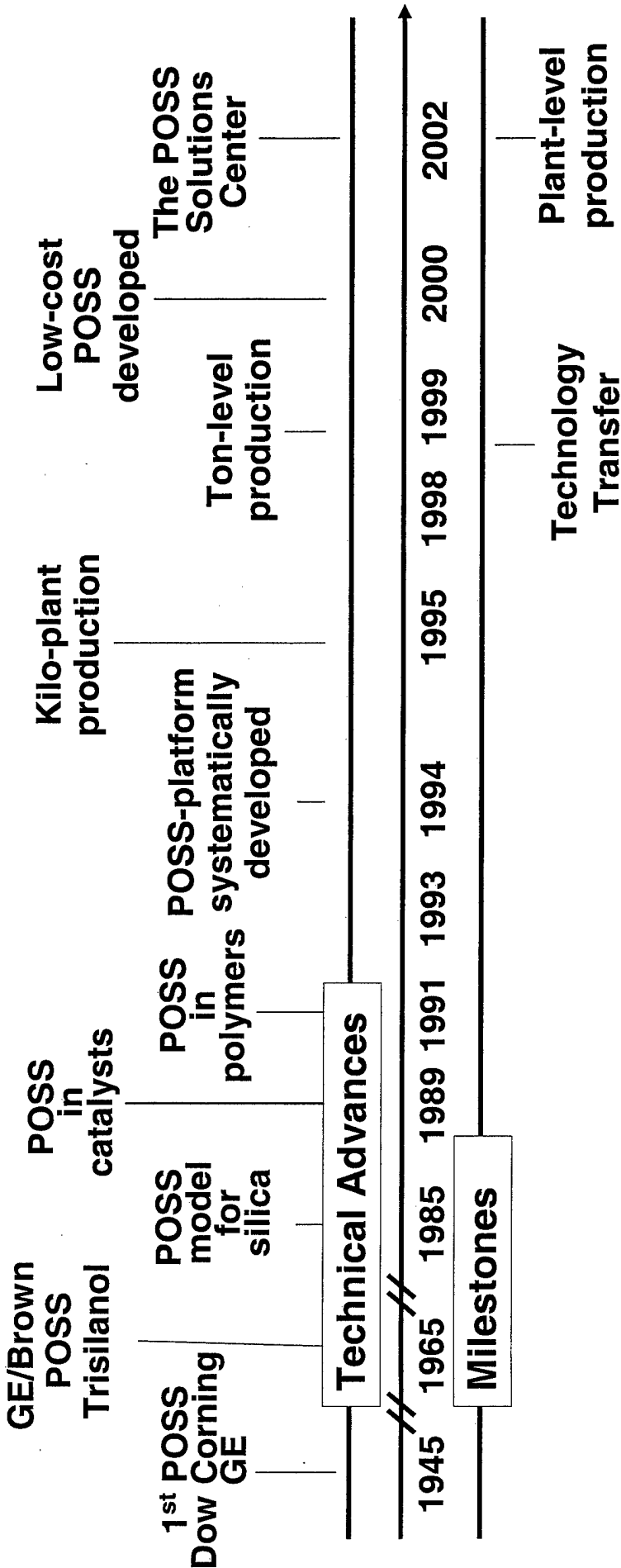
Critical & High-Risk Paths for Air Force Applications

(Insulation, Ducting, Lubricants, Space Materials)

Incorporation and R&D Testing by Numerous Companies



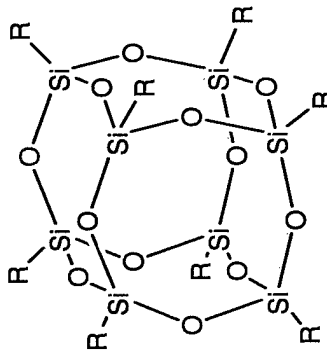
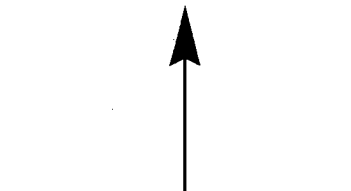
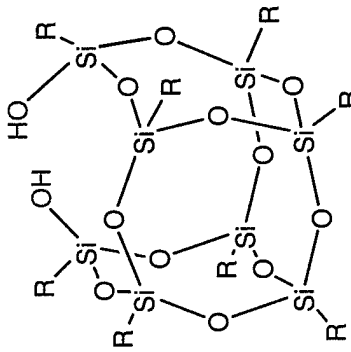
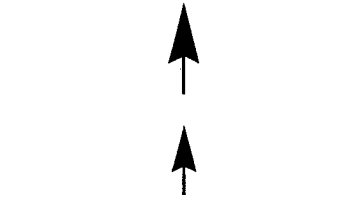
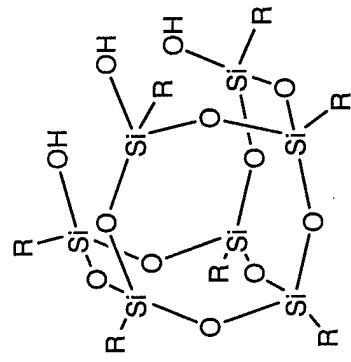
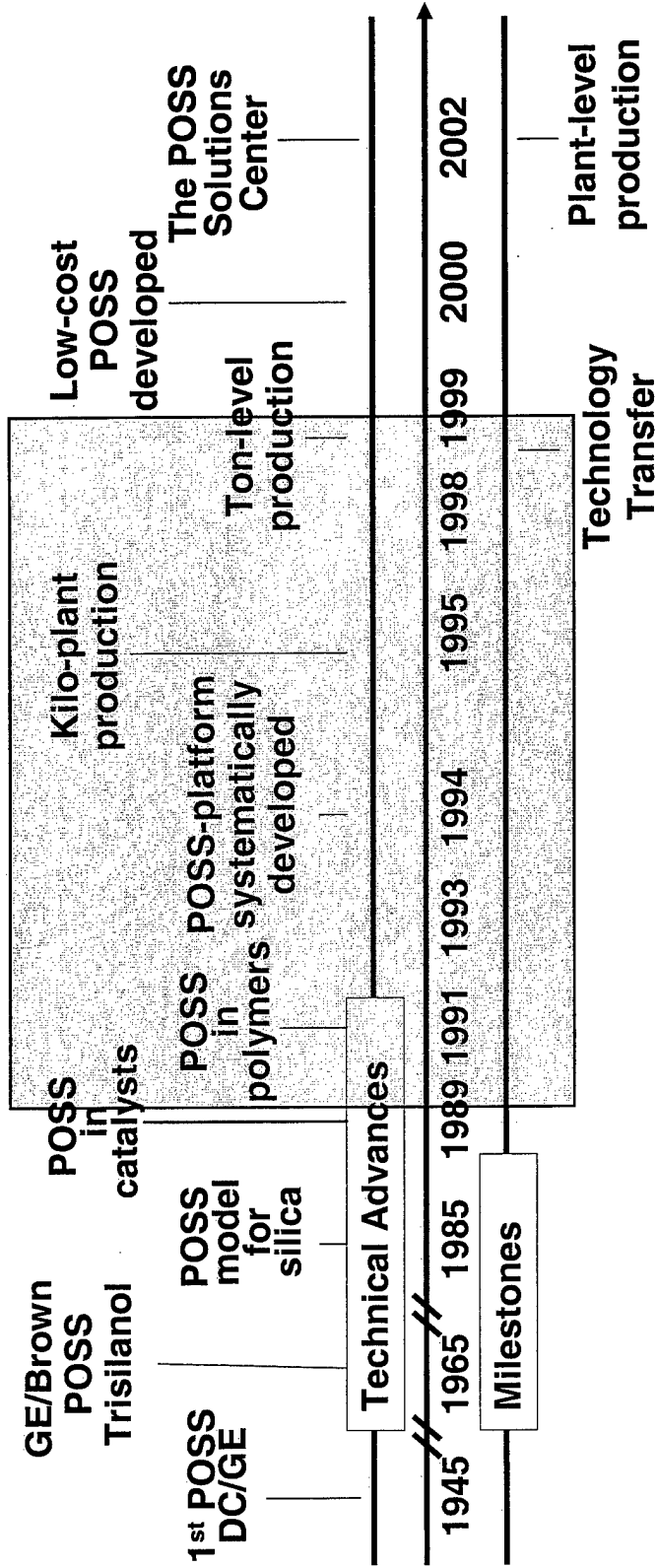
# POSS™-Technology Timeline



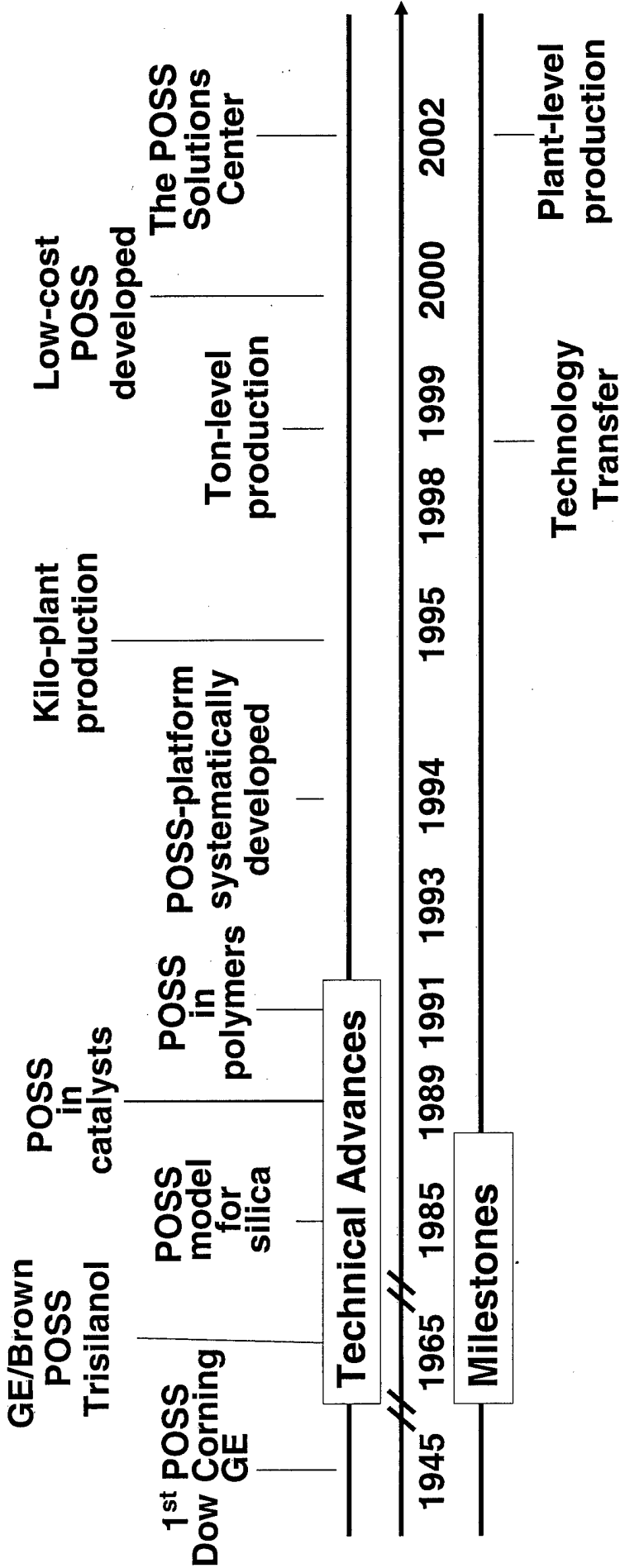
# UCL Air Force Hybrid Plastics

Chemistry      Polymers      Technology Transfer      Plant-level production      Commercial Solutions





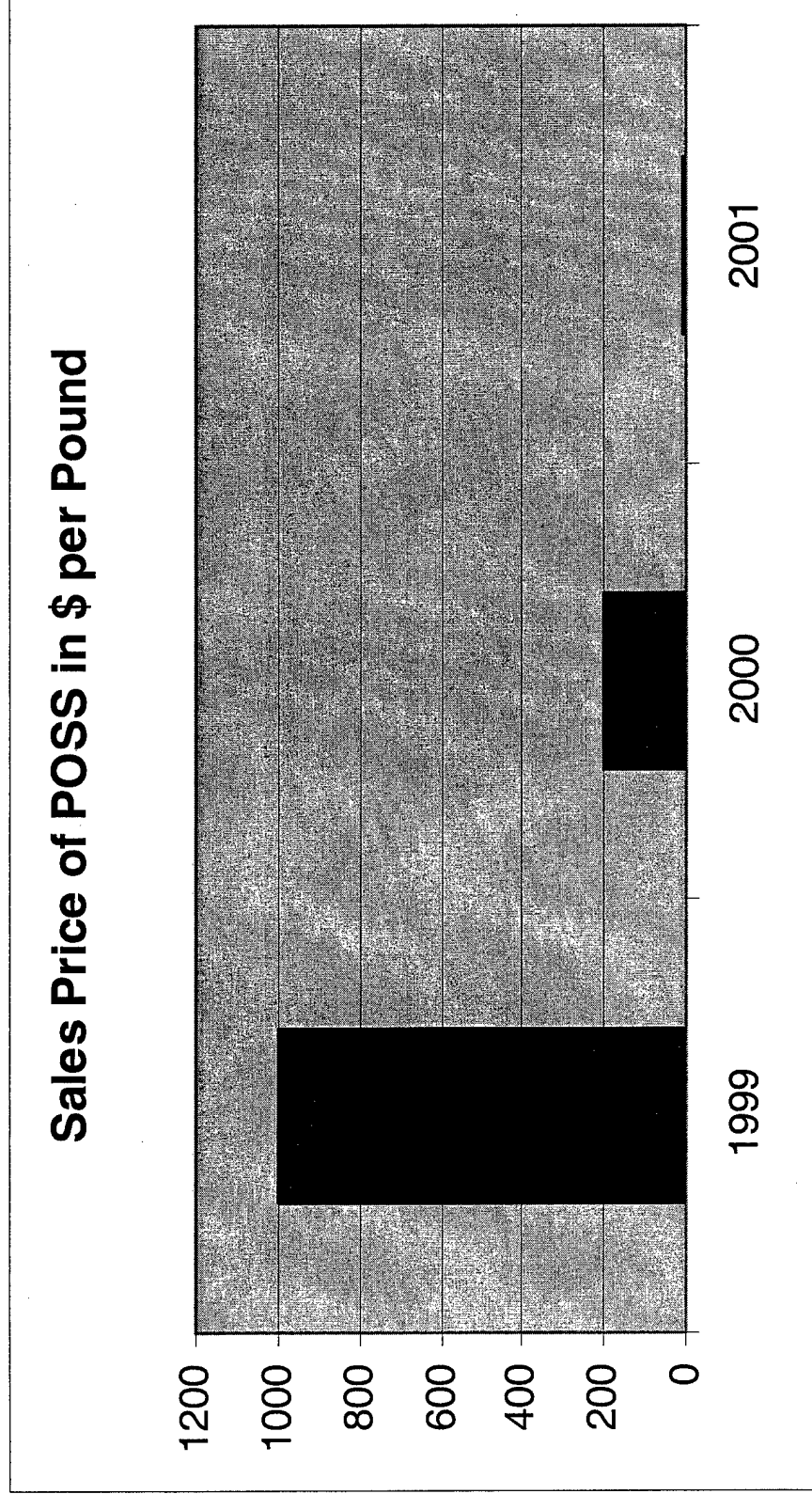
# POSS™-Technology Timeline

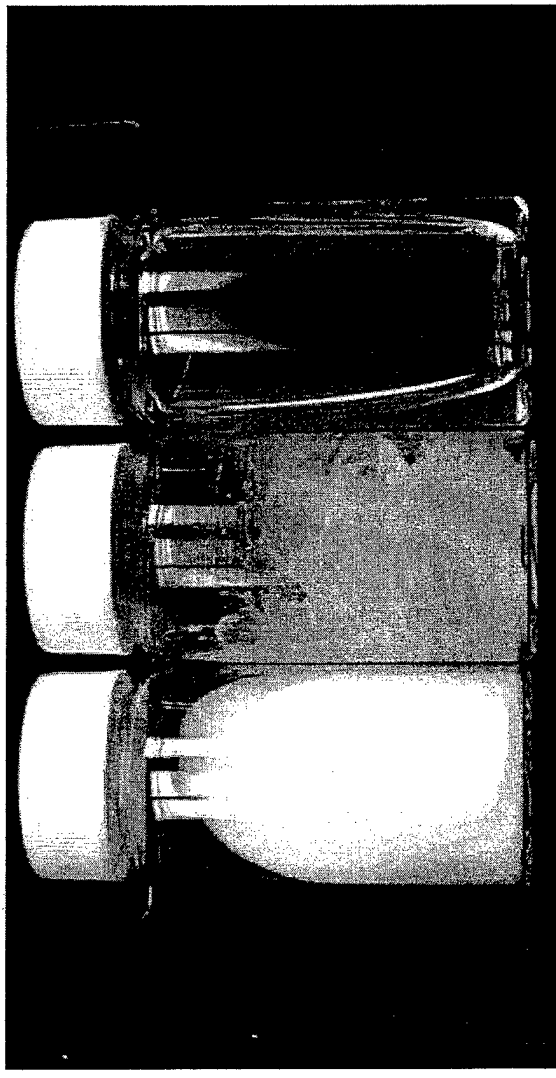
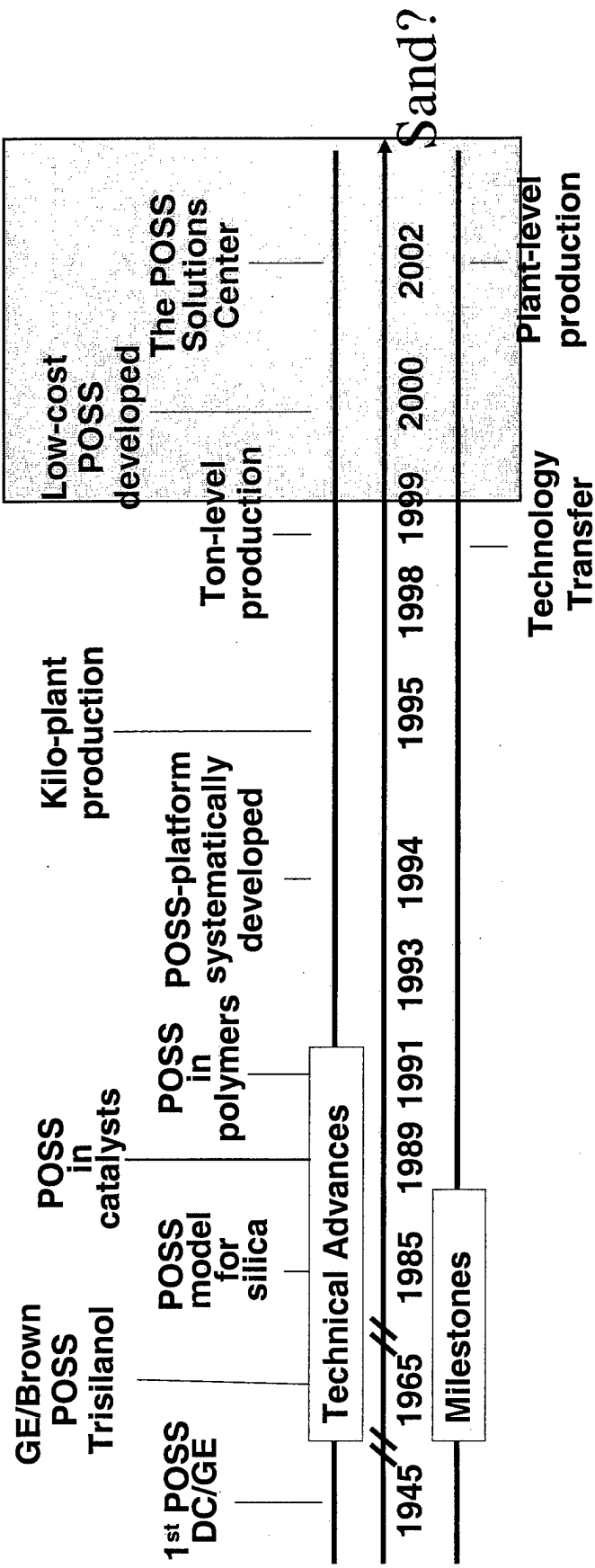


# UCL Air Force Hybrid Plastics

Chemistry      Polymers      Commercial Solutions

# ATP Funded Cost Reduction





**Crystalline Solids**

Wide melting range 24°C to 400°C+

**Waxes**

Wide viscosity range 40cSt. to 400cSt

**Liquids & Oils**

Wide viscosity range 40cSt. to 400cSt

# Summary

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The Air Force is heavily invested in POSS Applications Research and Development

Currently one application is being 'flight-tested' for a technology transition

New applications are being investigated (e.g., batteries, capacitors, radomes)

The technology transfer to Hybrid Plastics **IS** a success story with significant volume increase and price reduction

**POSS Nanotechnology Offers Versatility!!**