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Title:	NCT HE ROADMAP MEETING / LANL Capabilities and Perspectives
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Intended for:	Discussion at an NCT Roadmap Meeting scheduled for December 15th at LANL

Los Alamos
NATIONAL LABORATORY
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The presentation is a summary of LANL capabilities and perspectives on high explosives. it describes our high explosives research capabilities (firing sites and diagnostics), a list of the extent to which high explosive materials have been characterized at LANL, as well as LANL's perspectives on potential research direction for the NCT program.

NCT HE Roadmap Meeting
December 15th, 2010

LANL Capabilities and Perspectives

David Robbins

HE NCT Issues:

Many of the standard HE classification experiments, material property extraction analysis and modeling approaches cannot be directly applied to NCT relevant materials

- Low mass and energy density
- Long reaction zones (several mms to cms)
- Often possess highly heterogeneous structure (porous, granular)
- Non-molecular mixing of fuel and oxidizer
- Significant potential for dead zones
- Much of our HE capability based on near Dcj ideas
- The working fluid for a non-ideal HE comes from both the reaction zone and products

Addressing HE NCT Issues

Issues with NCT HE classification and modeling

- Classification of a large quantity of materials (inc. material variability) of HEs and inerts
  - Not realistic
- Develop capability to ``Bin'' materials according to various criteria?
  - Material structure, DSD classification, shock/thermal insult,...
  - Understand base materials in each class; develop a ``perturbative'' approach to classifying the broader range of materials

Encourage design of new experiments and models

- Many traditional CHE-based experiments and HE models are not suitable for non-ideals (e.g. cylinder tests, gauge experiments for detonation structure,standard programmed burn models,...).
- Suggestions for non-ideal HE appropriate experiments and models

Addressing HE NCT Issues

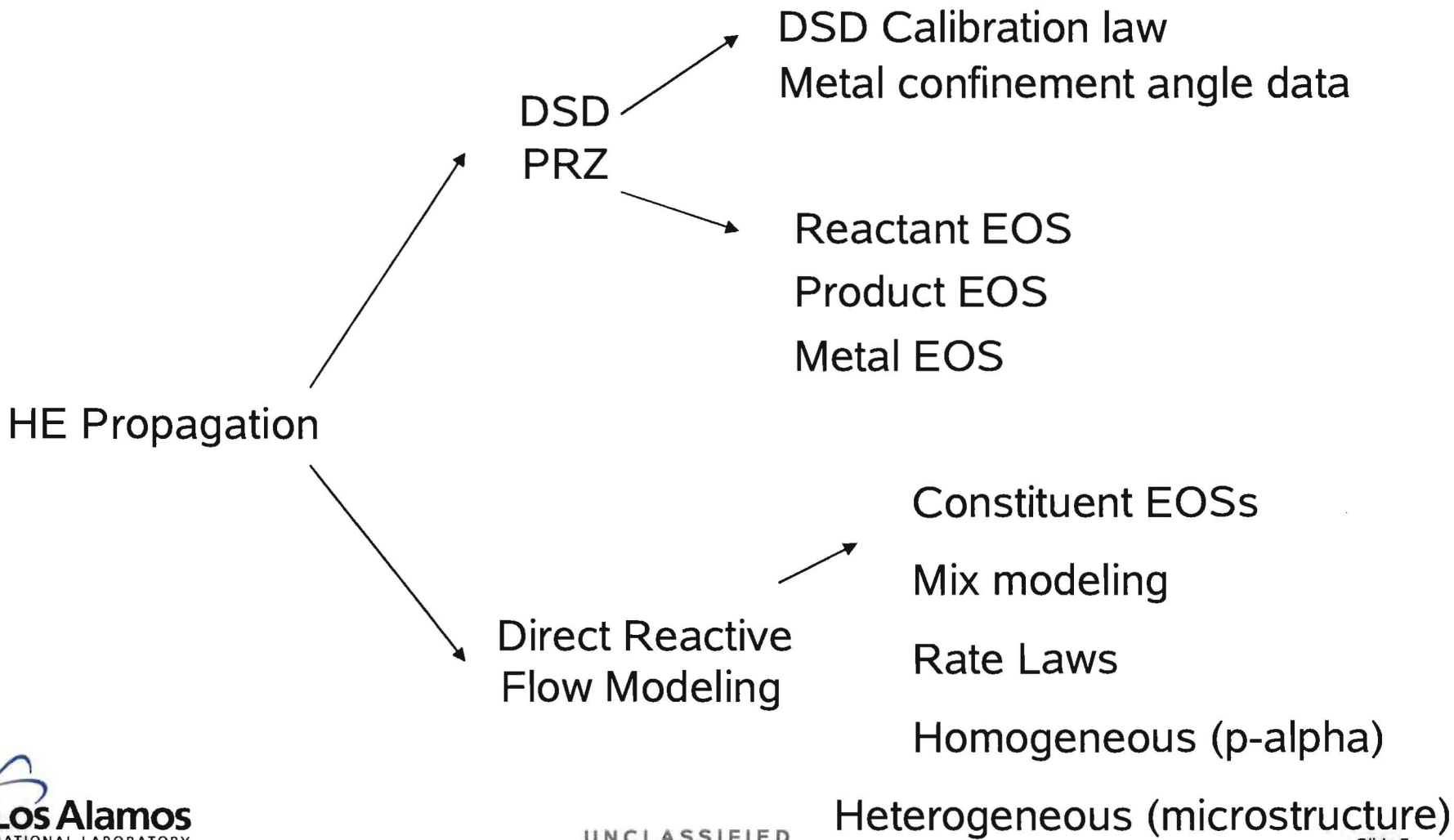
Non-ideal HE mixtures are not well controlled.

Does it make sense to be too concerned about the detailed characteristics rather than design experiments/models that capture the general trends.

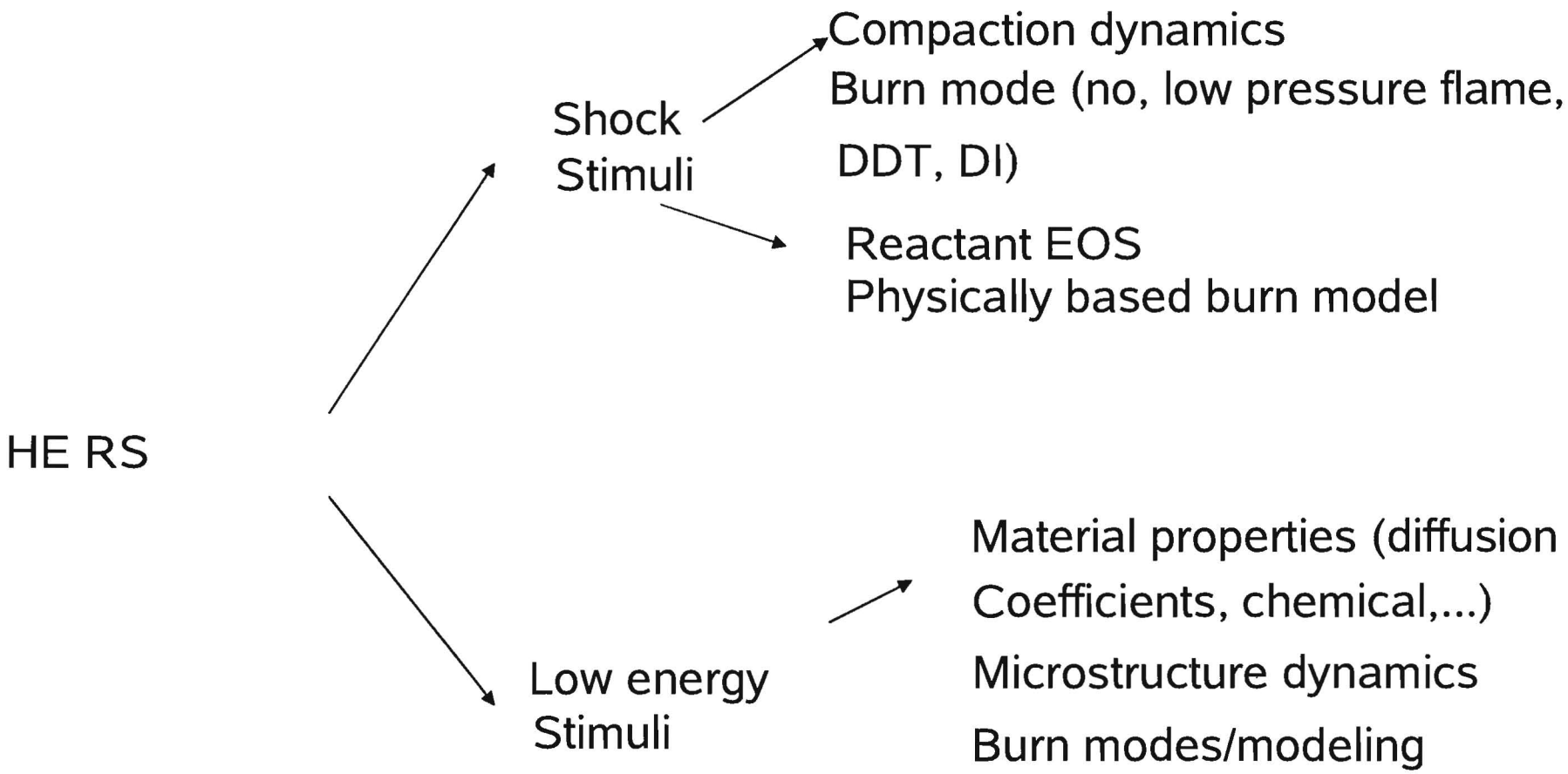
Database highlighting gaps in our current knowledge

Need for coherent and co-ordinated tri-lab effort

HE Propagation Requirements:



HE RS Requirements:



Experimental Capabilities

Capabilities

- Propagation
  - Rate sticks, cylinder test, diameter effect, critical diameter, front curvature, gap testing, corner turning, arc tests, material variability, confinement effect, sandwich tests, detonation wave profiles, DSD calibration, detonation mass spectrometry, gap tests,
- Initiation/EOS
  - Gun facilities, overdriven EOS,
- Insult
  - Bullet testing, fragment insult, water knife insult, shape charge insult

Extensive range of state-of-the-art diagnostics for HE characterization

Skid tests, drop tower, compatability testing,...

Extensive HE fabrication facilites

Experimental Capabilities

Capabilities

Very high speed imaging

streak cameras, high speed framing cameras,

X-ray imaging

protable X-ray flash machines (150keV, 450keV,600keV,1.2MeV),

VISAR, PDV, Schlieren Imaging, PLIF, PIV, 1- and 2-stage gas driven guns, 23-stage powder guns

Modeling Capabilities

HE and Metal EOS Group (T-1, lead)

- Extensive first principles and empirical EOS models for HE reactants, products, inert metals
- Shaw SESAME table formulations (recent non-ideal additions e.g. ANFO)

HE Reactive Flow Modeling Group (WX-9, lead)

- Extensive background in HE reactive flow model development and code integration
- Most recently developed a new more physical based reactive flow model for PBX 9502 that models dynamic initiation and failure

HE DSD group (XCP-4, lead – implementation, WX-9 model development)

- Developers of the Detonation Shock Dynamics capability for simulating detonation propagation. Implemented in a number of codes now including ALE3D.
- Recently developed improved programmed burn models specific to IHEs and NIHEs

Modeling Codes

LANL has a range of ASC program derived codes (inc. safety and propagation) and a research and development code (AMRITA) that can be successfully utilized by NCT

Significant investment to develop physics-based models of non-ideal HE that can be integrated into codes

Modeling Issues

Non-ideal HE systems are typically multi-phase and heterogeneous

- Limited experience with best practice for model development
  - More investment needed with ASC funding leverage

Unrealistic to model many formulations of same base HE

- E.g. ANFO, variations in density, stoichiometry, prill size, etc.
- Focus on developing a ``HE'' model
  - Investment in ``perturbative'' modeling required to extend from base model to deal with material variability

Ability to model HE RS VERY poor

- Substantial investment needed to understand response of heterogenous HE material to various energy stimuli.
- Related- Our ability to model dead zone generation in IHEs is poor – no understanding of the physics.

LANL FY11 Experimental Focus:

Propagation

Initiation

Render Safe

Essential LANL Capabilities & Facilities

HE fabrication and sensitivity testing

Firing sites with large load limits

Includes LANL collaboration with Energetics Materials Research and Testing Center (EMRTC) at NM Tech, Socorro, NM.

Precision diagnostic firing sites (chambers 8 & 9, PRAD, DARHT,...)

Support of non-ideal HE modeling capability

Essential LANL Capabilities & Facilities

In addition to unique site specific capabilities, many LANL firing sites have the following additional capabilities

High speed streak cameras; high speed framing cameras; VISAR; PDV; portable flash X-ray machines (150 keV, 450 keV, 600 keV, 2.3 Mev), 20 GHZ oscilloscopes.

LANL HE Experimental Capabilities (Firing Sites)

Firing Site	HE Limits (Derived/Admin)	Unique/Enhanced Capabilities/Diagnostics
Q-site East (TA-14-23/29)	6.5/5, 13/10, 26/20, 39/30, 65/30	Explosive Sensitivity Testing
Q-site West (TA-14-39)	?	Explosive Sensitivity Testing
Eenie (TA-36-3)	1000/500	DU/Uranium(?)
Meenie (TA-36-6)	5000/2000	Still open?
Minie (TA-36-8)	5000/2000	DU/Uranium(?)
Lower Slobbovia (TA-36-12)	5000/500	DU/Uranium(?)
Point 6 (TA-39-6)	500/200	High explosive pulsed power
Point 88 (TA-39-88)	2000	4 600kJ capacitor banks. High explosive pulsed power.
Chamber 5 (TA-40-5)	2/1	Detonator testing and firing. Booster and initiation systems testing. Particle image velocimetry (PIV). Schlieren imaging. PLIF.
Chamber 15 (TA-40-15)	150/1	Detonator testing and firing. Booster and initiation systems testing
Chamber 8 (TA-40-8)	10/5	Enclosed HE firing vessel. Hercules HE Laser Lab
Energetic Materials Research Testing Center. NM tech	20000	Large scale testing. Classified firing sites.
Advanced Proton Source	?	Static, high pressure diamond anvil cell

LANL HE Experimental Capabilities (Firing Sites)

Firing Site	HE Limits (Derived/Admin)	Unique/Enhanced Capabilities/Diagnostics
PRAD	10	Proton radiography, confinement vessel
DARHT	150/66	20MeV penetrating X-rays. Dual Axis. Be & Du capable
TA-40 (Chamber 9)	?	1-stage gas driven (0.1 to 1.5 km/s, 78 mm bore dia). 2-stage gas gun (1.0 to 3.5 km/s, 102/55 mm bore dia.) Embedded magnetic gauges. Shock trackers.
Anchyo Canyon (TA 39-69)	?	2-stage powder driven (1.5 to 7.5 km/s, 89/28 mm bore dia.) Uranium.
S-site		HE pressing/casting/machining. Vacuum capable.
Darla Tompson	?	?
Drop tower; skid test;synthesis, compatibility		

LANL HE Characterization Summary.

HE	Sens.	Cook-off	CO Model	Rate Stick	Cylinder test	Diameter Eff.	Critical Diam.	Front curvat.	Confinem. Eff.	Material Var.	DSD Calib.	Arc	product EOS	Corner Turn.	Gap Testing	Polyrho	Det. Mass Spect.	Shock Initiation	Reactant EOS	Det Wave prof.	HODSD Model	TOA/PB/DSD Simulation	Reactive Burn	Bullet test	fragment Insult	Water Knife Insult	Shape charge Ins.	Raman	Photosensitive
ANFO		X	X	X	X	X	X	X	X	X	X		X					X	X	X	X	X	X			x			x
ANFO Slurry	x					X		X	X		X		X					X	X		X		X						
AN													X					X	X									x	
UAN/urea/AN/ H20				X														X	X										
Black Powder		X	X																										
Bullseye		X	X	X	X	X	X	X	X		X		X					X	X			X							x
Densified Bullseye				X		X		X										X	X										
Comp-B		X	X	X	X	X	X						X										X	X				X	
C-4		X	X		X								X															X	x
Pydrodex		X	X																										
Semtex 1A		X	X		X													X	X									X	
Semtex 1H		X	X		X								X					X	X									X	
Semtex 10		X	X										X																x
TNT		X	X										X				x	X						x					
Sugar Mock																			X						x	x			
IMR 4198				X	X	X	X	X			X		X																
NM			X	X	X	X	X	X	X	X	X		X				x	X	X	X									
Sensitized NM				X			X											X	X	X									
Deuterated NM				X			X										x	X	X	X									
Bromo-NM				X			X											X	X									X	
Heterogenized NM				X			X	X										X	X				X						
H2O2 > 99%																		X	X										
H2O2 90%				X			X												X										
RDX			X																									X	
RDX single crystal																		X	X										
PETN			X					X																				X	
PETN Single Crystal																		X	X										
HMX single crystal																		X	X										
TATB										X				x			x	X										X	
FEFO				X			X											X	X										
IPN isopropyl Nitrate																		X	X										
PBX 9404					X	X	X	X			X															X		X	
PBX 9501		X			X	X	X	X			X		X					X	X	X			X	X	X			X	
PBX 9502				X	X	X	X	X	X	X	X	x	X	x				X	X	X	X	X	X						X	
LX-17											X							X				X	X						

HE	Sens.	Cook-off	CO Model	Rate Stick	Cylinder test	Diameter Eff.	Critical Diam.	Front curvat.	Confinem. Eff.	Material Var.	DSD Calib.	Arc	product EOS	Corner Turn.	Gap Testing	Polyrho	Det. Mass Spect.	Shock Initiation	Reactant EOS	Det Wave prof.	HODSD Model	TOA/PB/DSD Simulation	Reactive Burn	Bullet test	fragment Insult	Water Knife Insult	Shape charge Ins.	Raman	Photosensitive
Ammonium perchlorate																												x	
ANT																												x	
Bartol																												x	
CL20																												x	
Cl-HNBP																												x	
Red Dot																													x
DAATO3.5																													x
DAAF	x			x	x	x	x	x		x				x	x	x		x										x	
DNAT																												x	
2,4 DNT																												x	
EGDN																												x	
HMX (delta)																												x	
HMX (delta)																												x	
HMX (beta)																												x	
HMX/NTO 25/75																												x	
HMX-d8																												x	
HNS																												x	
Hexanitromanitol																												x	
Nonanitroterphenyl																												x	
nitroguanidine																												x	
NTO																												x	
Octol																												x	
Pentanitromanitol																												x	
Potassium Nitrate																												x	
TATP																												x	
TNA																												x	
TNAZ																												x	
TNP																												x	
TNT																												x	
1,3,5-trinitrobenzene																												x	
urea nitrate																												x	
70%H2O2-sugar	x			x	x			x	x				x						x										
70%H2O2-glycerine	x			x	x			x	x				x																
70%H2O2-drink mix1	x			x	x				x				x						x										
70%H2O2-drink mix2	x			x	x			x	x				x						x										
70%H2O2isopropanol	x				x			x	x				x																
70%H2O2-NM	x			x																									

HE	Sens.	Cook-off	CO Model	Rate Stick	Cylinder test	Diameter Eff.	Critical Diam.	Front curvat.	Confinem. Eff.	Material Var.	DSD Calib.	Arc	product EOS	Corner Turn.	Gap Testing	Polyrho	Det. Mass Spect.	Shock Initiation	Reactant EOS	Det Wave prof.	HODSD Model	TOA/PB/DSD Simulation	Reactive Burn	Bullet test	fragment Insult	Water Knife Insult	Shape charge Ins.	Raman	Photosensitive
DCDNAB	x																												
BTDAONAB	x																												
BANTAONAB	x																												
DMONAB	x																												
TAG-azide	x																												
DPX-01				x																									
DPX-02				x																									
LAX-117-4		x		x											x														
LAX-117-13		x								x					x														
PBX – 9504				x										x															
LAX-120.1		x		x			x	x		x					x														
PBXN-7				x			x	x		x					x														
PBXW-14				x						x					x														
LAX-117-6		x		x											x														
LAX-117-8		x		x											x														
LAX-117-10		x		x			x	x							x														
LAX-112				x										x															
Fox-7/Kel-F				x												x													
RX-55-AY				x												x													
DAAF/TATB				x						x																			
TATB/KelF3700										x																			
TATB/Viton										x																			
TATB/THV										x																			
TATB/Oxy 461										x																			
TATB & LFC-1/FC 2175										x																			
LX-07				x										x															
DAAF & 3% KelF				x										x		x		x											
DAAzF				x																									
ADAAF				x																									
TAGDNAT				x																									
SMX				x																									
FOX-7				x																									
NO2Tz				x																									
TAGNO2Tz				x																									
BPTAP				x																									
DHT				x																									
DAAT				x																									
TNAZ				x																									
ANTA-NO				x																									
LAX-112				x																									
LAX-116				x																									

HE	Sens.	Cook-off	CO Model	Rate Stick	Cylinder test	Diameter Eff.	Critical Diam.	Front curvat.	Confinem. Eff.	Material Var.	DSD Calib.	Arc	product EOS	Corner Turn.	Gap Testing	Polytho	Det. Mass Spect.	Shock Initiation	Reactant EOS	Det Wave prof.	HODSD Model	TOA/PB/DSD Simulation	Reactive Burn	Bullet test	fragment Insult	Water Knife Insult	Shape charge Ins.	Raman	Photosensitive
RX-55-AE				X																									
HMX/ZnO/Vito				X																									
R-salt				X																									
X-0535				X																									
TATB/DAAzF				X																									
DNAT				X																									
BguTz-2HCl04				X																									
FeN4BIM				X																									
NM+nono Al				X																									
TAGzT				X		X			X						x														
TBX01-TAGzT+nAl+G				X																									
TBX02-TAGzT+nAl+Vi				X																									
LAX-134				X																									
PBXN109				X	X								X																
PBXN109				X	X								X																
PBXN109				X	X								X																
PBXN109				X	X								X																
HMX+Al+GAP/				X	X								X																
HMX+Si+GAP/				X	X																								
DHT				X																									
AP+sugar				X		X	X		X																				
AP+Al				X		X	X		X																				
AP+Dodecane				X	X	X	X		X																				