Overview of PR&PP Case Study
for the
Example Sodium Cooled Fast Reactor

Presented at

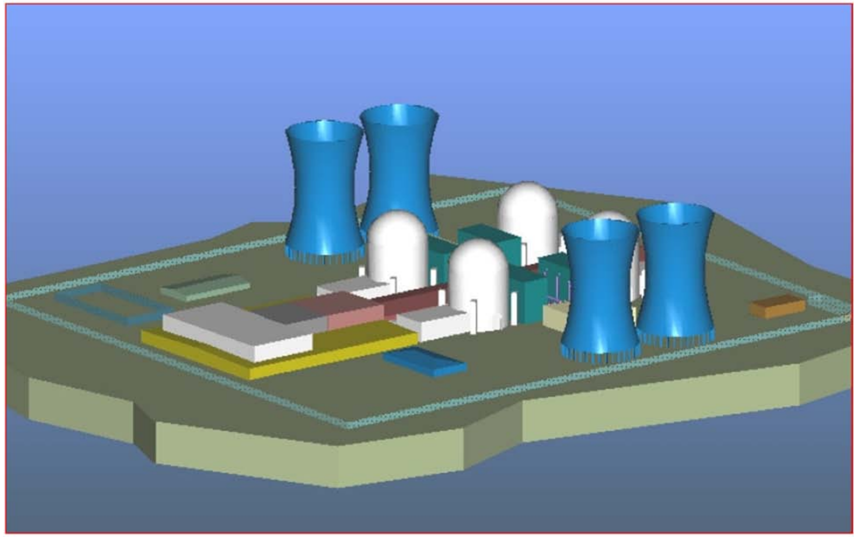
Workshop on
PR&PP Evaluation Methodology
for Gen IV Nuclear Energy Systems

Tokyo, Japan
22 February, 2011

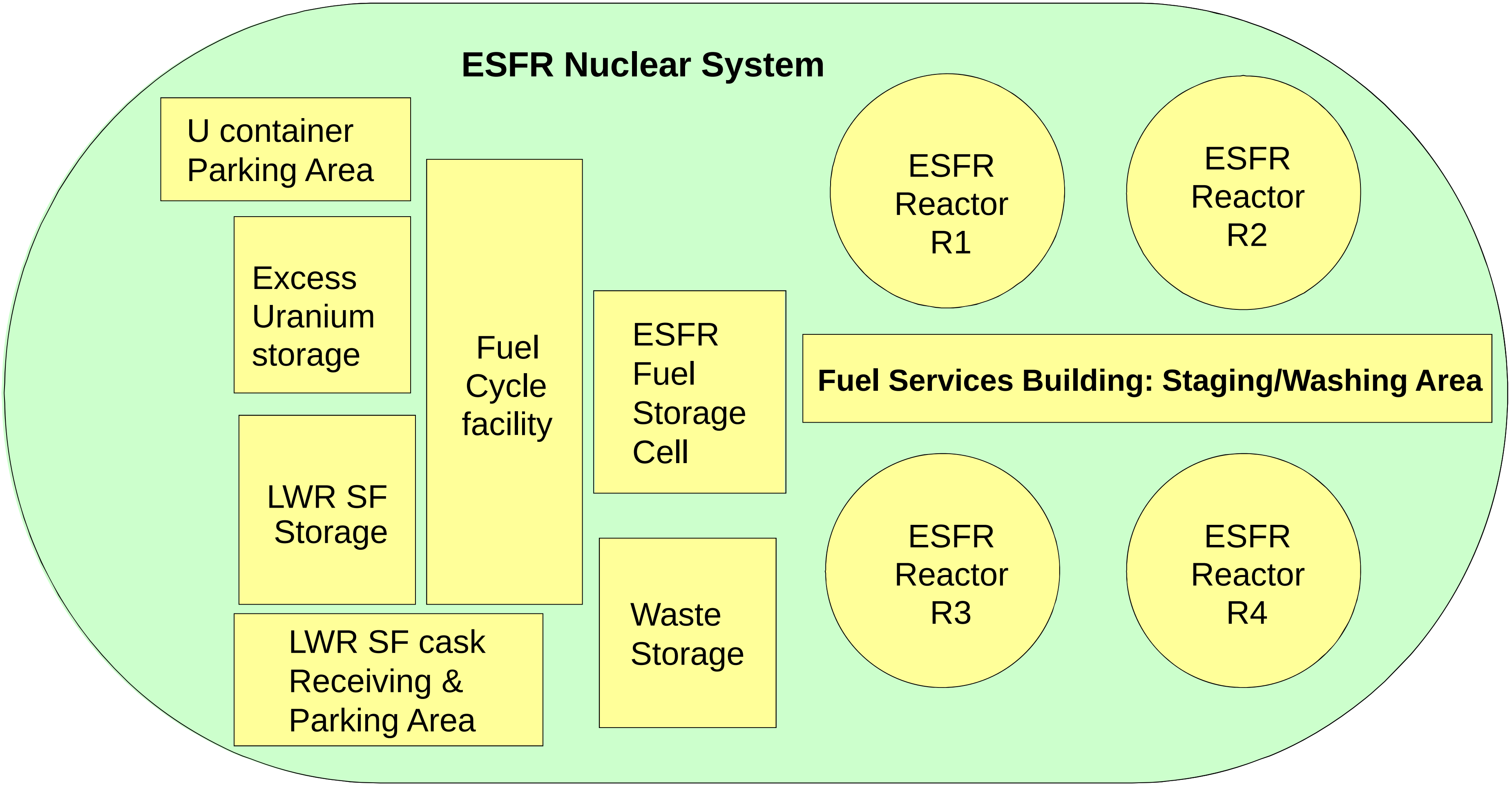
Background

The PRPP Working Group has developed and tested the PR&PP Evaluation Methodology through a series of studies for a hypothetical Example Sodium Fast Reactor (ESFR)

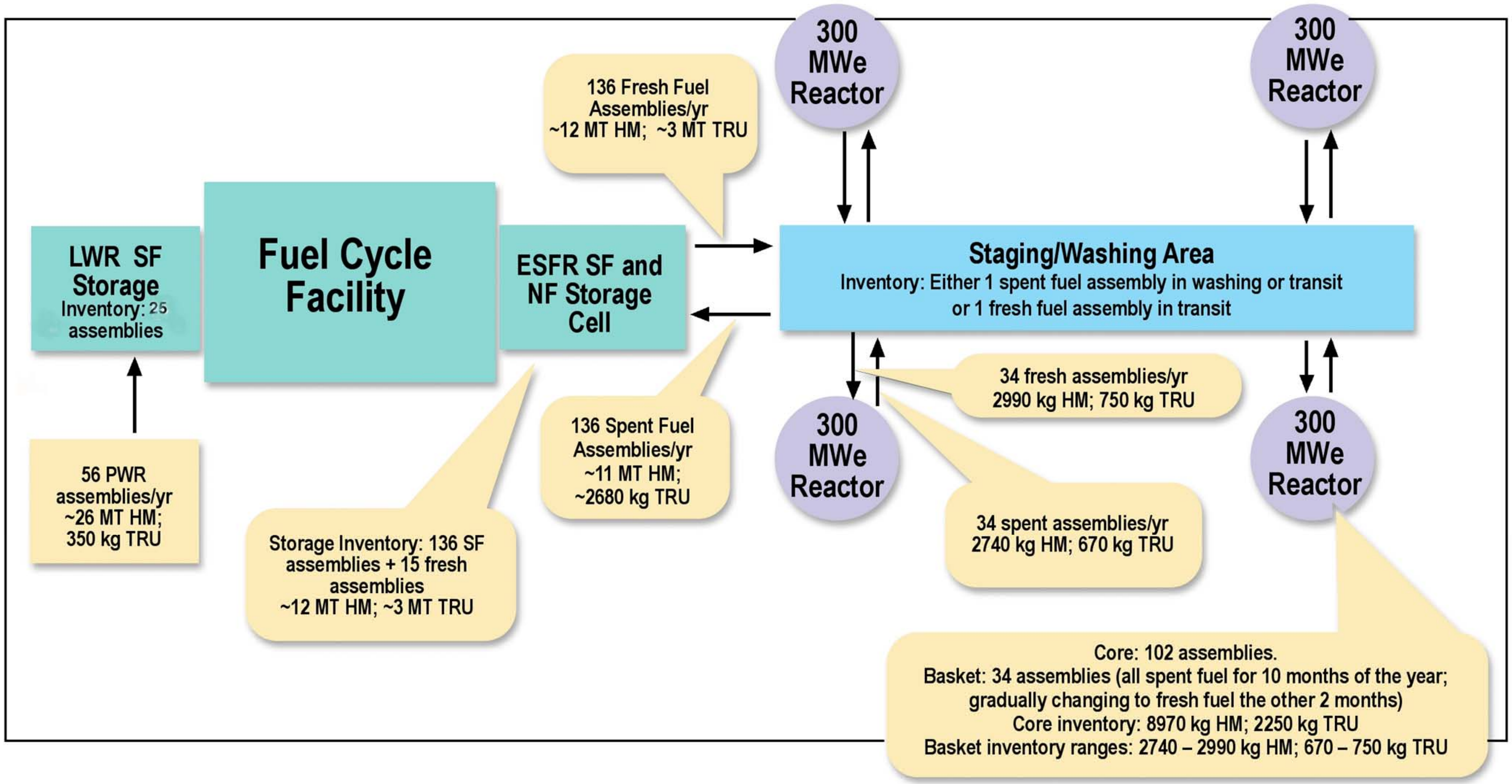
- ***Latest "Case Study" performed in 2007-2008 is a more comprehensive assessment of the entire ESFR reactor/fuel cycle system***
- ***Case Study report submitted for GIF EG review in June '09, final report issued in October 2009, and posted on GIF public web site:***
  http://www.gen-4.org/Technology/horizontal/proliferation.htm
- ***Case Study objectives***
  - *Demonstrate the Methodology for an entire system*
  - *Confirm applicability at different levels of design detail*
  - *Provide examples of PR&PP evaluations for future users of the Methodology*
  - *Determine the needs for further methodology development*



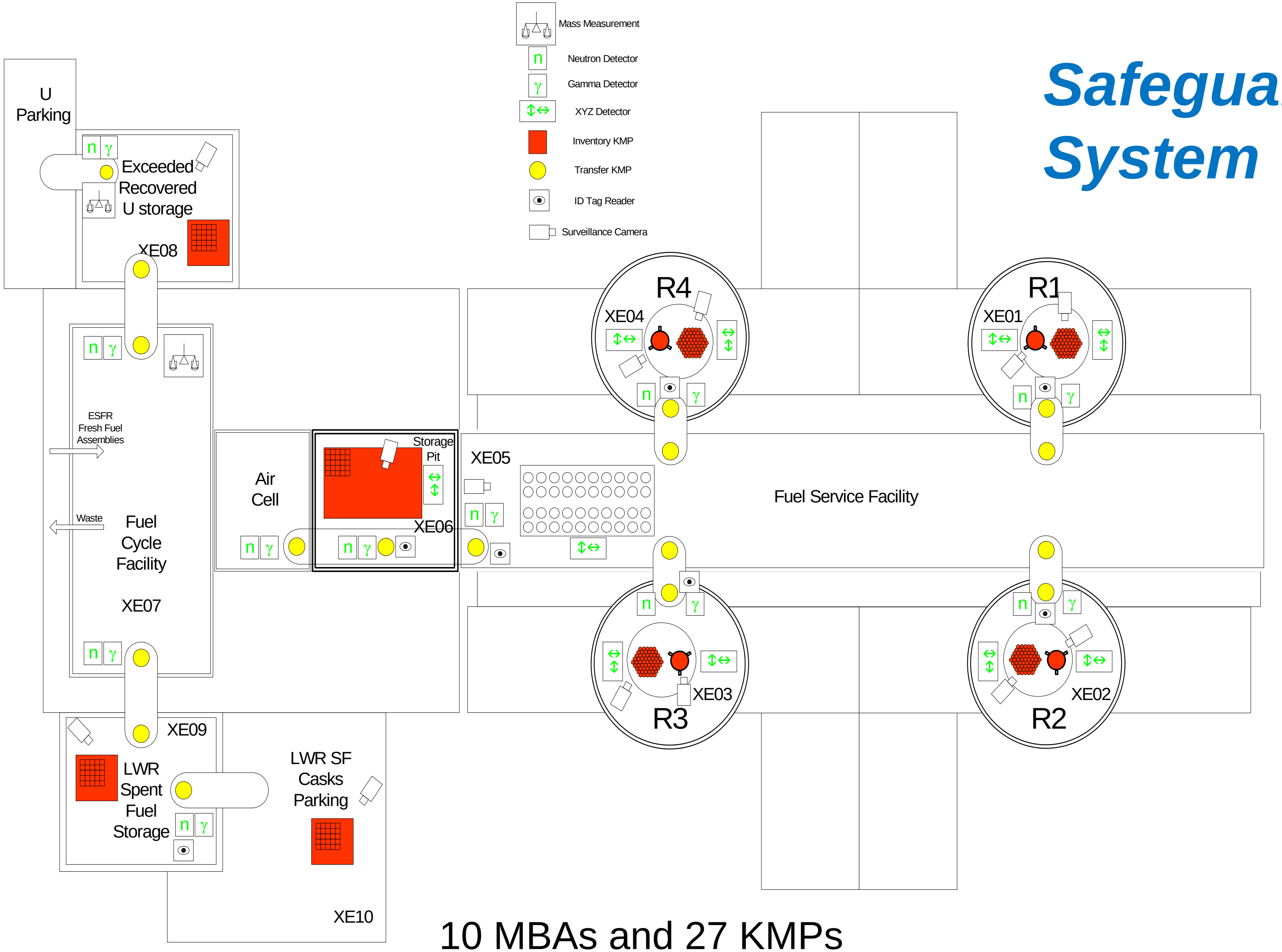
Baseline ESFR Nuclear System Elements



Baseline ESFR System Material Flows



Safeguards System

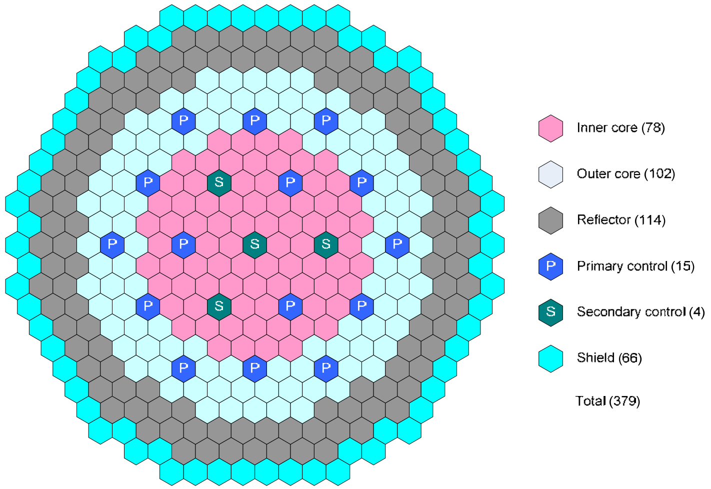


10 MBAs and 27 KMPs

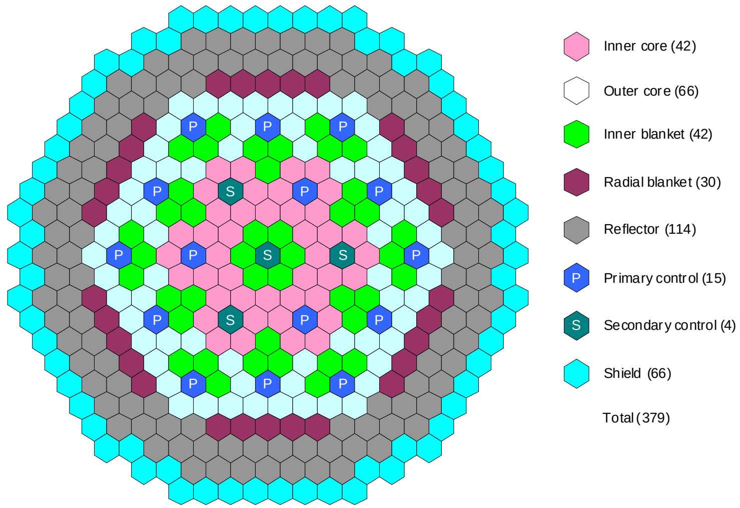
ESFR System Variations

1000 MWth (350 MWe) reactor capacity

- ***Reference core**: Conversion ratio (CR) for transuranic actinides (TRU) = 0.73*
- ***Variation 1**: Lower CR (0.22) requiring fuel of higher enrichment*
- ***Variation 2**: Higher CR (1.00) representing a break-even core without fertile blankets*



- ***Variation 3**: Still higher CR (1.12) representing a breeding core with both external and internal U blankets*



Overview of Analysis Approach

- ***ESFR design, operation and safeguards/protection information was compiled***
- ***Three PR and one PP "threat scenarios" were defined for system evaluation***
- ***Four working subgroups were formed, each focused on a threat scenario***
  - *Identified possible "targets" and "pathways" for each threat scenario*
  - *Selected a few targets and pathways for analysis based on their attractiveness to the adversary*
  - *Characterized ESFR system PR&PP performance/response by estimating PR&PP "measures" for these targets and pathways*

Threat Scenarios

PR

- ***Adversary**: Host state in control of ESFR facilities*
- ***Objective**: to obtain at least one significant quantity (SQ) of plutonium for at least one nuclear weapon*
- ***Capabilities**:*
  - *typical of a developed industrial nation*
- ***Strategies**:*
  1. *Concealed <u>diversion</u> of nuclear material from ESFR facilities*
  2. *Concealed <u>misuse</u> of the ESFR to produce weapons-usable material*
  3. *"<u>Break-out</u>" and overt misuse or diversion*

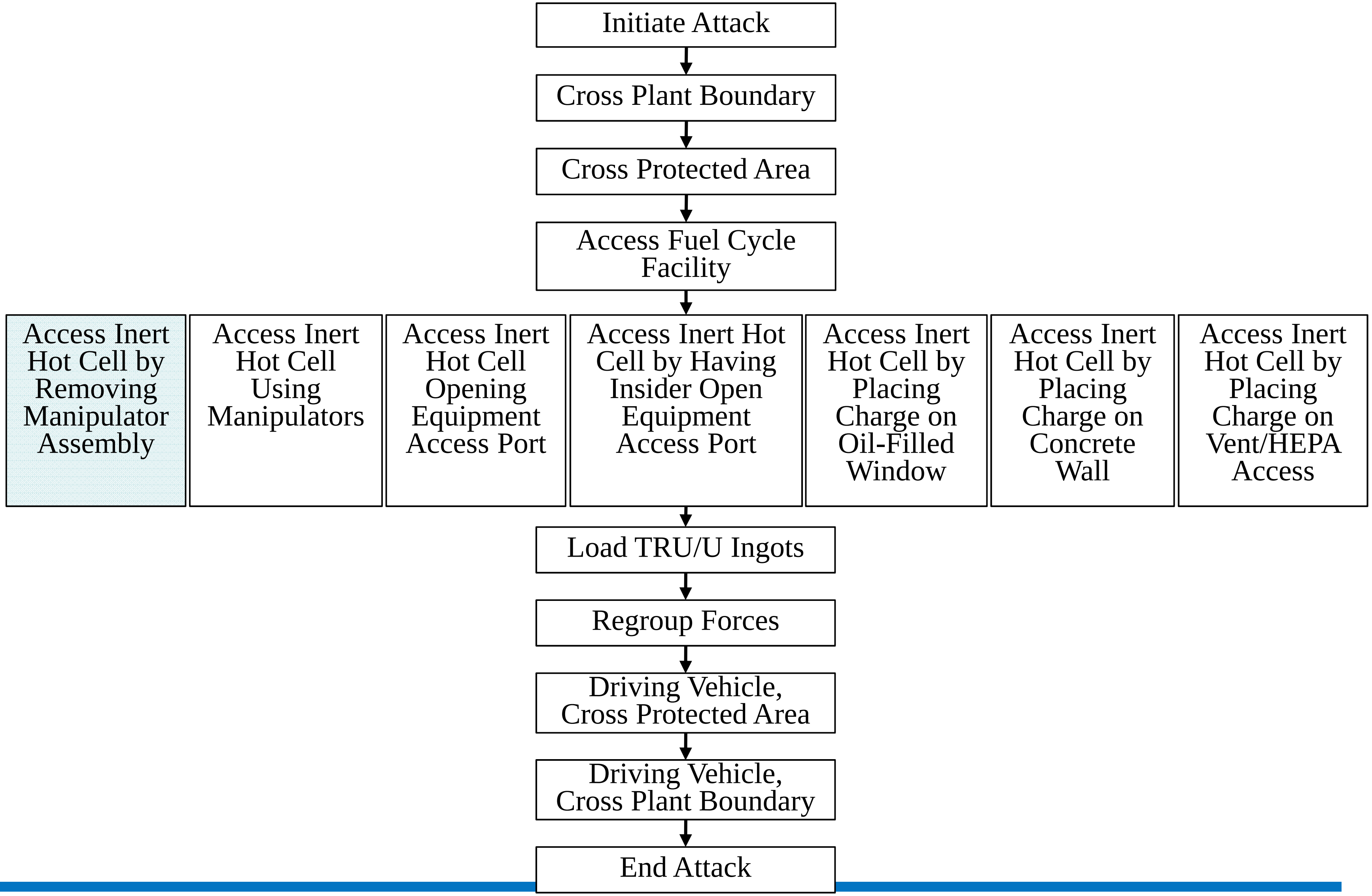
PP

- ***Adversary**: Military trained sub-national/ terrorist group (12 outsiders & 1 insider)*
- ***Objective**: <u>Theft</u> of one SQ of nuclear weapon material*
  - *Radiological sabotage also considered*
- ***Capabilities**:*
  - *Knowledge of plant layout, basic PP features, and theft targets of opportunity*
  - *Ability to acquire and use assault equipment and weapons, including specialized explosives and armored vehicles*
- ***Strategy**:*
  1. *Surprise assault on ESFR material storage areas*

Representative Case Study Results

Threat Scenario	Diversion		Misuse	
	Reference ESFR Diversion Pathway 1	Reference ESFR Diversion Pathway 2	Reference ESFR, CR=0.73 Misuse Pathway 1	ESFR Variation 1, CR=0.22 Misuse Pathway 1
Pathway Description	Diversion of TRU/U ingot material using a new fuel assembly hardware container and transporting it out of the FCF through the assembly hardware portal.	Diversion of TRU/U ingot material using recovered uranium container and transporting it out through recycled U container portal.	Irradiation of ad-hoc U targets in reactor(s) and Pu recovery in a clandestine reprocessing facility.	Irradiation of ad-hoc U targets in reactor(s) and Pu recovery in a clandestine reprocessing facility.
Technical Difficulty (TD)	Low	Low	Medium	Medium
Proliferation Time (PT)	Medium	Medium	Medium	Medium
Proliferation Cost (PC)	Very Low	Very Low	Very Low	Very Low
Material Type (MT)	Medium (RG Pu)	Medium (RG Pu)	Low (WG Pu)	Low (WG Pu)
Detection Probability (DP)	Medium	High	Low to High	Low to High
Detection Resource Efficiency (DE)	High	High	Low to High	Low to High

Adversary Sequence Diagram for Theft of TRU/U Ingot



Methodology Lessons Learned

- ***Methodology can be applied during the conceptual stage of system development and design***
- ***Completeness in identifying attractive targets and pathways is important***
  - *They can be systematically identified, and plausible scenarios can be described*
- ***Assessment frequently requires assumptions about the system and its safeguards/protection***
  - *These assumptions provide the basis for functional requirements and design bases documentation for the system*
- ***Assessment requires considerable technical expertise on system design and operation, as well as on safeguards and physical protection measures***
- ***Greater standardization of the methodology and its use is needed***
  - *More detailed guidance for assessments should be provided*

Insights from Analysis of Proliferation Pathways

- ***Diversion** pathway analysis requires consideration of how attractive the material is to potential proliferators for use in a weapons program, how difficult it would be to access and remove the material, and whether the facility can be designed and operated in such a manner that all plausible acquisition pathways are covered by a combination of intrinsic features and extrinsic measures*

- ***Misuse** pathways analysis requires consideration of potentially complex combinations of processes to produce weapons-usable material – i.e., it is not a single action on a single piece of equipment but rather an integrated exploitation of various assets and system elements.*

- ***Breakout** pathways analysis found that breakout is a modifying strategy within the diversion and misuse threats and can take various forms that depend on intent and aggressiveness, and ultimately on the proliferation time targeted by a proliferant state.*

Insights from Analysis of PP Pathways

- ***The theft (and sabotage) analyses found that multiple targets and pathways exist***
  - *The most attractive theft target materials appeared to be located in a few target areas*
- ***While containment of the adversary is adequate to prevent theft, a deterrence strategy that denies adversary access to targets is required to prevent sabotage***
- ***The proximity of theft and sabotage targets will likely require a deterrence strategy because the PP system will not be able to determine adversary intent (i.e., theft or sabotage) early enough***
  - *Implies need for a robust perimeter detection system and effective use of the passive barriers provided by hot cell radiation shielding structures and reactor passive safety systems*

Backup Slides

PR&PP Assessment Paradigm

CHALLENGES → SYSTEM RESPONSE → OUTCOMES

Threats

PR
- Concealed diversion/misuse
- Breakout
- Clandestine facility

PP
- Theft
- Sabotage

PR & PP

Intrinsic
- Physical & technical design features

Extrinsic
- Institutional arrangements

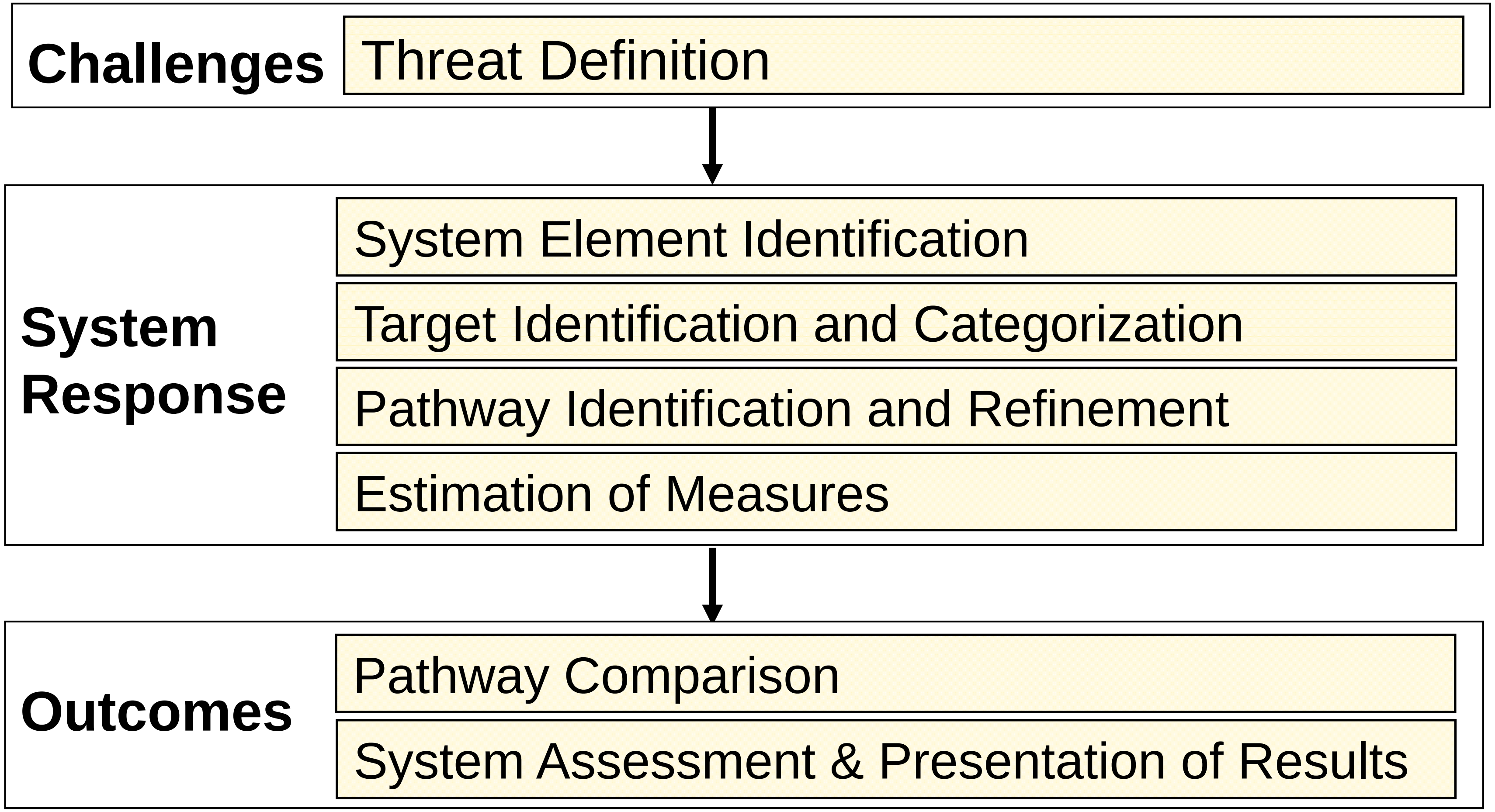
Assessment

Measures and Metrics

Paradigm is consistent with standard approaches to safety assessment

Methodology Report: http://www.gen-4.org/Technology/horizontal/PRPPEM.pdf

PR&PP Evaluation Framework

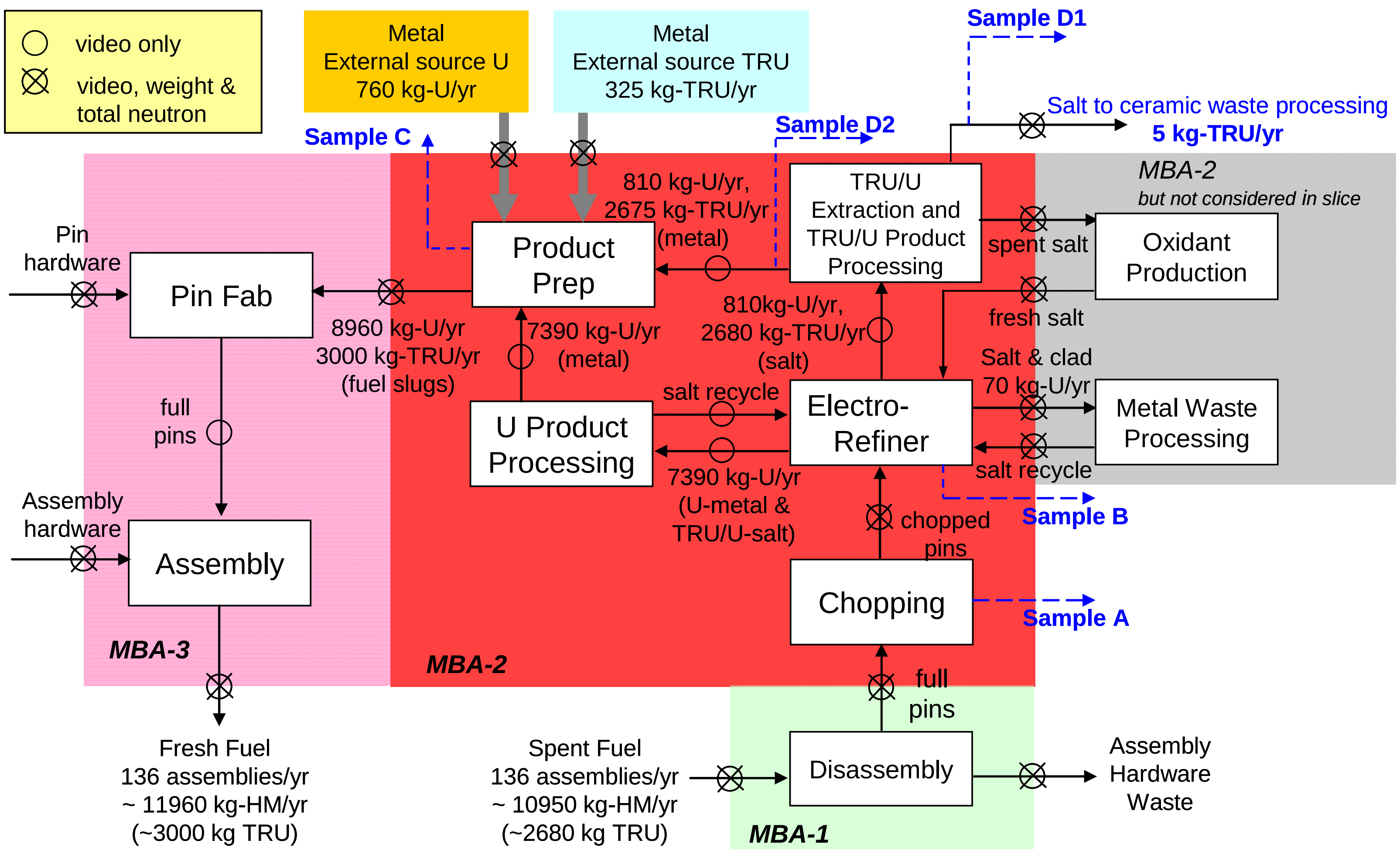


ESFR System

A hypothetical Gen IV system that includes, at a single site:

- *The power plant(s) – 4 identical SFRs, based on the AFR-300 Concept*
- *Staging area/subassembly washing station – A building adjacent to the reactor buildings used for fresh and spent fuel in transit and for washing spent fuel subassemblies prior to storage*
- *Fuel Storage building – A facility to store fuel discharged from the reactors prior to processing and re-fabricated fuel to be transferred to the reactors*
- *Fuel Cycle Facility – A spent fuel recycle facility employing pyroprocess separations and associated fuel refabrication*
- *LWR Spent Fuel Storage Facility – A facility to store LWR spent fuel assemblies that are used as a source of make up fissile material for the (actinide burner) reactors*

Baseline ESFR Fuel Cycle Facility Annual Throughput and Preliminary Safeguards Approach



Variation of Core Parameters with Conversion Ratio

	Reference Configuration TRU CR = 0.73	Variation 1 TRU CR = 0.22	Variation 2 TRU CR = 1.00 No Blankets	Variation 3 TRU CR = 1.12 Radial & Internal Blankets
Fuel composition (core / blanket)	Metallic U-TRU-10Zr / -	Metallic U-TRU-20Zr / -	Metallic U-TRU-10Zr / -	Metallic U-TRU-10Zr / U-Zr
Cycle length @ 90% CF, months	12	6.6	12	12
Number of assemblies (core / blanket)	180 / -	180 / -	180 / -	108 / 72
Number of batches (core / internal / radial)	4 / - / -	8 / - / -	4 / - / -	4 / 4 / 6
Residence time, days (core / internal / radial)	1300/ - / -	1445/ - / -	1300/ - / -	1300/1300/1970
Pins per assembly (core / internal / radial)	271 / - / -	324 / - / -	271 / - / -	271 / 127 / 127
Structural pins per assembly	0	7	0	0
Average TRU enrichment, %	22.1	58.5	14.4	19.3
Fissile/TRU conversion ratio	0.84 / 0.73	0.55 / 0.22	0.99 / 1.00	1.07 / 1.12
HM/TRU inventory at BOEC, MT	13.2 / 2.9	6.9 / 3.9	18.5 / 2.8	20.5 / 2.5
Discharge burnup (ave/peak), MWd/kg	93 / 138	185 / 278	67 / 103	92 /146
TRU consumption rate, kg/year	81.6	241.3	-1.2 (gain)	-33.2 (gain)

Actinide Inventory & Mass Flows for Nominal CR

1/3 Core Mass, kg

	Inner Core Mass					Outer Core Mass				
Cycle	0	1	2	3	4	0	1	2	3	4
U-234	0.00	0.02	0.03	0.04	0.05	0.00	0.03	0.05	0.08	0.10
U-235	0.81	0.64	0.50	0.40	0.32	0.97	0.83	0.71	0.61	0.52
U-236	0.00	0.04	0.06	0.08	0.10	0.00	0.03	0.06	0.08	0.10
U-238	402.60	390.50	378.76	367.39	356.37	482.92	472.93	463.17	453.62	444.27
NP237	1.09	0.97	0.87	0.79	0.72	2.91	2.63	2.38	2.17	1.98
PU236	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
PU238	2.49	2.29	2.18	2.07	1.96	4.30	4.15	4.11	4.07	4.00
PU239	43.11	43.40	43.35	43.03	42.52	77.11	73.48	70.26	67.37	64.77
PU240	26.92	26.20	25.55	24.95	24.39	46.31	45.36	44.39	43.41	42.42
PU241	3.81	3.77	3.72	3.65	3.58	7.97	7.54	7.18	6.87	6.59
PU242	6.14	5.92	5.71	5.51	5.32	11.01	10.75	10.49	10.22	9.96
AM241	2.55	2.24	1.99	1.78	1.60	5.33	4.96	4.63	4.33	4.06
AM242	0.19	0.19	0.18	0.17	0.16	0.29	0.32	0.33	0.33	0.33
AM243	2.07	2.02	1.96	1.91	1.85	3.51	3.46	3.41	3.36	3.31
CM242	0.01	0.14	0.15	0.14	0.13	0.02	0.20	0.23	0.22	0.21
CM243	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02
CM244	1.30	1.33	1.34	1.34	1.34	2.06	2.08	2.09	2.09	2.09
CM245	0.35	0.34	0.34	0.34	0.34	0.53	0.52	0.52	0.52	0.52
CM246	0.19	0.19	0.19	0.19	0.19	0.28	0.28	0.28	0.28	0.28
Total mass(kg)	493.63	480.19	466.89	453.80	440.95	645.52	629.57	614.30	599.64	585.52
TRU mass (kg)	90.22	89.00	87.53	85.88	84.11	161.63	155.75	150.31	145.25	140.53

	1/3 core	full core		
Charge HM (kg)	4383.5	13150.6	Avg. Assembly Charge HM (kg)	73.058894
Discharge HM (kg)	4270.9	12812.6	Avg. Assembly Discharge HM (kg)	71.180987

	1/3 core	full core				
Charge TRU (kg)	965.6	2896.7	Avg. Assembly Charge TRU (kg)	16.092919	TRU SQ eq. (kg)	8.78
Discharge TRU (kg)	938.4	2815.1	Avg. Assembly Discharge TRU (kg)	15.639328	TRU SQ eq. (kg)	8.76

Targets and Pathways

- ***Specific nuclear material and/or equipment "targets" were identified by each threat/scenario subgroup***
  - *Consideration was given to material stocks and flows; material attributes and accessibility; vulnerability of equipment and processes to misuse, replication, or sabotage*
- ***"Pathways" were generated and analyzed by each subgroup …*** *Sequences of events/actions followed by the proliferant state or sub-national adversary to achieve its objective (e.g., diversion, misuse, theft)*
  - *Proliferation (host state) pathways considered pre-acquisition preparation, acquisition, and post-acquisition material processing stages; weapon fabrication was not considered.*
  - *PP (sub-national) pathways considered only the steps involved in the acquisition stage*
  - *Reasonable assumptions were made regarding detection by safeguards or interruption by protective force*

Diversion Targets and Pathways

- ***Diversion subgroup selected five targets for analysis***
  - *TRU metal from electrorefiner processing*
  - *Waste containing TRU metal from electrorefiner cleanout*
  - *Cask of LWR fuel assemblies*
  - *LWR spent fuel assembly*
  - *Recycled uranium metal*
- ***Generated a total of 10 pathways***
- ***Performed a coarse estimation of the measures for each diversion pathway (for the reference configuration, CR=0.73)***
  - *Addressing the entire pathway as a whole*
- ***Effects of conversion ratio variations were reviewed but not analyzed in detail***
  - *Variations judged to have minor impact on the outcome, limited mainly to the isotopic composition of the TRU targets*

Misuse Targets and Pathways

- ***Misuse subgroup identified 6 misuse targets (i.e., equipment and technologies that can be misused or replicated):***
  - *Separation of weapon-usable material in FCF*
  - *Irradiation of uranium (breeding) pins in reactor(s)*
  - *Dismantlement of irradiated uranium pins in FCF*
  - *Fabrication of breeding material in FCF*
  - *Misuse of skills and knowledge in clandestine site*
  - *Replication of technology in clandestine site*
- ***Analyzed the irradiation of U pins in reactor(s) and Pu recovery in a clandestine reprocessing facility***
- ***Generated fairly detailed pathway including acquisition as well as pre- and post-acquisition processing steps***
- ***Estimated the PR measures for this pathway for CR=0.73 (reference) and CR=0.22***

Breakout Targets and Pathways

- ***Breakout subgroup chose five targets for analysis:***
  - *Diversion of stockpiled ESFR fresh fuel – plutonium separation from in a clandestine PUREX facility*
  - *Misuse of facility to irradiate fertile material in-core*
  - *Misuse of facility to irradiate fertile material in storage baskets*
  - *Misuse of facility to extract high-plutonium-purity TRU in the FCF*
  - *Diversion of inner blanket assemblies from "breeder" case (Variation 3) – plutonium separation in a clandestine PUREX facility*
- ***Identified different breakout strategies:***
  - *Immediate breakout: Proliferant state immediately acts on decision to break out – minimum time, minimum complexity of proliferation activities*
  - *Delayed, optional breakout: Proliferant state covertly misuses or diverts with intent to break out if/when detection occurs – medium time, medium complexity*
  - *Delayed, intended breakout: Proliferant state covertly misuses or diverts under a predetermined schedule for breakout – maximum time, maximum complexity*
- ***Estimated proliferation time (PT) measure for each target and breakout strategy as an indication of target attractiveness***

Theft Targets and Pathways

- ***Theft subgroup identified many potential theft targets***
  - *Ingots of U metal and TRU/U metal (FCF inert hot cell)*
  - *Makeup TRU material from reprocessed LWR spent fuel (inert hot cell)*
  - *ESFR fresh fuel slugs and fuel pins (inert hot cell)*
  - *ESFR fresh fuel assemblies (air hot cell or fuel staging/washing)*
  - *ESFR spent fuel assemblies (fuel staging/washing or FCF air hot cell)*
  - *Full length ESFR spent fuel pins (FCF air hot cell)*
  - *Chopped ESFR spent fuel pins (FCF inert hot cell)*
  - *Cask of LWR fuel assemblies (LWR Cask shipping/receiving)*
  - *LWR spent fuel assemblies (LWR spent fuel storage)*
- ***Outlined pathways to targets using Adversary Sequence Diagrams (ASDs)***
- ***Analyzed pathway for theft of TRU/U metal ingot from FCF inert hot cell***
- ***Limited pathway to removal of the target to the site boundary, did not address activities beyond the site boundary***
- ***Estimated PP measures***
  - *Determined probability of detection and delay time for each pathway segment*
  - *Used Estimate of Adversary Sequence Interruption (EASI) software to estimate the probability of adversary success for different response times by protective force*

PR Measures & Metrics

Measures and Metrics	Metric Scales Bins (Median)	Proliferation Resistance
Proliferation Technical Difficulty (TD) Example metric: Probability of pathway failure from inherent technical difficulty considering threat capabilities	0-5% (2%)	Very Low
	5-25% (10%)	Low
	25-75% (50%)	Medium
	75-95% (90%)	High
	95-100% (98%)	Very High
Proliferation Cost (PC) Example metric: Fraction of national resources for military capabilities	0-5% (2%)	Very Low
	5-25% (10%)	Low
	25-75% (50%)	Medium
	75-100% (90%)	High
	>100% (>100%)	Very High
Proliferation Time (PT) Example metric: Total time to complete pathway	0-3 mon (2 mon)	Very Low
	3 mon-1 yr (8 mon)	Low
	1-10 yr (5 yr)	Medium
	10 yr-30 yr (20 yr)	High
	>30 yr (>30 yr)	Very High
Fissile Material Type (MT) Example metric: Dimensionless ranked categories (HEU, WG-Pu, RGPu, DB-Pu, LEU); interpolation based on material attributes	HEU	Very Low
	WG-Pu	Low
	RG-Pu	Medium
	DB-Pu	High
	LEU	Very High
Detection Probability (DP) Example metric: Cumulative detection probability	A	Very Low
	B	Low
	C	Medium
	D	High
	E	Very High
Detection Resource Efficiency (DE) Example metric: GW(e) years of capacity supported (or other normalization variable) per Person Days of Inspection (PDI) (or inspection $)	<0.01 (0.005 GWyr/PDI)	Very Low
	0.01-0.04 (0.02 GWyr/PDI)	Low
	0.04-0.1 (0.07 GWyr/PDI)	Medium
	0.1-0.3 (0.2 GWyr/PDI)	High
	>0.3 (1.0 GWyr/PDI)	Very High

Material Type Description

HEU = high-enriched uranium, nominally 95% 235U;
WG-Pu = weapons-grade plutonium, nominally 94% fissile Pu isotopes;
RG-Pu = reactor-grade plutonium, nominally 70% fissile Pu isotopes;
DB-Pu = deep burn plutonium, nominally 43% fissile Pu isotopes;
LEU = low-enriched uranium, nominally 5% 235U.

Detection Probability

A - Significantly lower cumulative detection probability than the IAEA detection probability and timeliness goal for depleted, natural, and LEU uranium.
B - 50% in 1 year (This equates to IAEA detection probability and timeliness goal for 1 significant quantity of depleted, natural, and LEU uranium).
C - 20% in 3 months, 50% in 1 year (This equates to IAEA detection probability and timeliness goal for 1 significant quantity of spent fuel/irradiated material).
D - 50% in 1 month, 90% in 1 year (This equates to IAEA detection probability and timeliness goal for 1 significant quantity HEU/separated Pu).
E - Significantly greater cumulative detection probability than the IAEA detection probability and timeliness goal for HEU/separated Pu.

PP Measures & Metrics

Metrics	Range/Value			
	High	**Medium**	**Low**	**Nil**
Probability of Detection, P_d	$1 > P_d \geq 0.9$	$0.9 > P_d \geq 0.8$	$0.8 > P_d \geq 0.2$	$0.2 > P_d = 0$
	0.95	0.85	0.5	0.1
Delay Time, t_d (minutes) Nominal value	$60 \geq t_d > 30$ 45	$30 \geq t_d > 10$ 20	$10 \geq t_d > 1$ 5.5	$1 \geq t_d = 0$ 0.5
Response Time, t_r (minutes) Nominal value	$1 \geq t_r = 0$ 0.5	$10m \geq t_r > 1m$ 5.5	$30m \geq t_r > 10m$ 20	$60m \geq t_r > 30m$ 45m
Measures	**Range/Value**			
	High	**Medium**	**Low**	**Nil**
Probability of Adversary Success, PAS Nominal value	$1 > P_s \geq 0.8$ 0.9	$0.8 > P_s \geq 0.5$ 0.65	$0.5 > P_s \geq 0.1$ 0.3	$0.1 > P_s = 0$ 0.05
PP Resources, PPR (% Operating Cost) Nominal value	>10% 10	10%>%>5% 5	5%>%>0% 1	0 0
Consequences, C_t (SNM Theft)	1 SQ of unirradiated or irradiated direct use material	1 SQ of unirradiated indirect use material	1 SQ of irradiated indirect use material	Unsuccessful theft

- Probability of Interruption, $P_I = f(P_d, t_d, t_r)$;
- Assume PAS = 1 – P_I for coarse pathway for conceptual facilities

Proliferation Resistance Segment Measure Estimates Related to a Misuse Pathway for Baseline Design and Design Variation 0

Segment	TD	PT	PC	MT	DP	DE
1 Host state acquires natural uranium (or DU if available)	Very low to low	Very low to medium	Very low	NA	Very low	Low
2 Host state prepares dummy uranium pins outside the ESFR site	Very low to low	Low	Very low	NA	Very low	Low
3 Host state introduces dummy pins into the ESFR site and then into the fuel assembly station of the FCF	Very low	Very low to low	Very low	NA	Very low	Very high
4 Host state assembles ESFR dummy fresh fuel assemblies made up by uranium target pins and standard ESFR fresh fuel pins	Medium	Very low	Very low	NA	Low to high	Very high
5 Host state transfers dummy assemblies from the FCF to in-vessel storage baskets	Very low	Low	Very low	NA	Very low	Medium
6 Host state loads dummy assemblies into outer ring of reactor core (during refueling)	Very low	Very low	Very low	NA	Very low	Very high
7 Host state irradiates dummy assemblies for 12 months	Very low	Low	Very low	NA	Very low	Very high
8 Host state unloads dummy assemblies from reactor core into in-vessel storage basket (during subsequent refueling) and leaves them there for cooling	Very low to medium	Medium	Very low	NA	Low to medi um	High to very high
9 Host state transfers dummy assemblies out of in-vessel storage basket to the FCF	Very low	Medium	Very low	NA	Very low	Medium
10 Host state recovers dummy pins at the FCF and transfers them to a clandestine facility	Medium	Very low	Very low	NA	Low to high	High to very high
11 Host state recovers plutonium at the clandestine facility	Low	Very low to medium	Very low	Low (WG Pu)*	Very low to low	Low
Overall Aggregated Value	Medium	Medium	Very low	Low (WG Pu)*	Low to high	Low to high

*WG Pu=weapons grade plutonium.

Proliferation Resistance Segment Measure Estimates Related to a Misuse Pathway for Design Variation 1

Segment	TD	PT	PC	MT	DP	DE
1 Host state acquires natural uranium (or DU if available)	Very low to low	Very low to medium	Very low	NA	Very low	Low
2 Host state prepares dummy uranium pins outside the ESFR site	Very low to low	Low	Very low	NA	Very low	Low
3 Host state introduces dummy pins into the ESFR site and then into the fuel assembly station of the FCF	Very low	Very low to low	Very low	NA	Very low	Very high
4 Host state assembles ESFR dummy fresh fuel assemblies made up by uranium target pins and standard ESFR fresh fuel pins	Medium	Very low	Very low	NA	Low to high	Very high
5 Host state transfers dummy assemblies from the FCF to in-vessel storage baskets	Very low	Low	Very low	NA	Very low	Medium
6 Host state loads dummy assemblies into outer ring of reactor core (during refueling)	Very low	Very low	Very low	NA	Very low	Very high
7 Host state irradiates dummy assemblies for 6.6 months	Very low	Very Low	Very low	NA	Very low	Very high
8 Host state unloads dummy assemblies from reactor core into in-vessel storage baskets (during subsequent refueling) and leaves them there for cooling	Very low to medium	Medium	Very low	NA	Low to medium	High to very high
9 Host state transfers dummy assemblies from in-vessel storage baskets to the FCF	Very low	Medium	Very low	NA	Very low	Medium
10 Host state recovers dummy pins at the FCF and transfers them to a clandestine facility	Medium	Very low	Very low	NA	Low to high	High to very high
11 Host state recovers plutonium at the clandestine facility	Low	Very low to medium	Very low	Low (WG Pu)*	Very low to low	Low
Overall Aggregated Value	Medium	Medium	Very low	Low (WG Pu)*	Low to high	Low to high

*WG Pu=weapons grade plutonium.