Report on
Developing Industrial Cost Estimates
for ITER Systems of Possible Interest to the US

For Discussion with FESAC

Gaithersburg, MD

March 5, 2003

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of the US ITER Cost-Estimating Team

Situation Assessment / Purpose of this Talk

- **Exploratory discussions over in-kind contributions are already underway. The US has been invited to submit its levels of interest on 85 procurement packages by April 1, for discussion during the April 8-16 meetings.**

- **To enable the preparation of the inputs, both programmatic priorities and costs should be considered.**

  - PROGRAMMATIC: In September, FESAC provided significant information on the priorities, objectives, guidelines, etc., for US participation ITER

  - COST: Building on those guidelines and utilizing existing information from the ITER project, a multi-institutional group has begun to address the "costs" of the most desirable packages.

➢ **This talk invites FESAC to engage in the process, particularly regarding strategy.**

- **The new Burning Plasma PAC will be charged with providing more tactical input on the cost-estimation processes and the levels of interest.**

The US ITER Negotiator's "Instrument and Control Panel" for In-Kind Contributions

Facts				Instruments	Controls
ITER Systems	Value (%)	US Cost (package / supporting program)	US Interest (high, medium, low, none)	Previous Offers (all parties)	Next US Offer
Machine Core	51%	$??M / $??M	None - High?	?%/ ?%/... total=?%	?%
Auxiliaries	35%	$??M / $??M	None - Medium?	?%/ ?%/... total=?%	?%
Heating / Current Drive	7%	$??M / $??M	None - High?	?%/ ?%/... total=?%	?%
Diagnostics and CODAC	7%	$??M / $??M	Medium - High?	?%/ ?%/... total=?%	?%
	100%	$??M / $??M		?%/ ?%/...; total= ?%	total=?% $???M / $???M

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	100%	$??M / $??M		?%/ ?%/...; total= ?%	total=?% $???M / $???M

ITER "Value"

ITER Team prepared 85 "Procurement Packages"

with Cost Estimation Workbooks (structure for work-elements, quantities of work, and rates)

EU/JA/RF parties performed cost-estimates

EU

JA

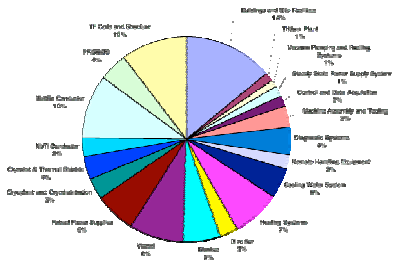
RF

labs, universities and industry estimated quantities of work and rates

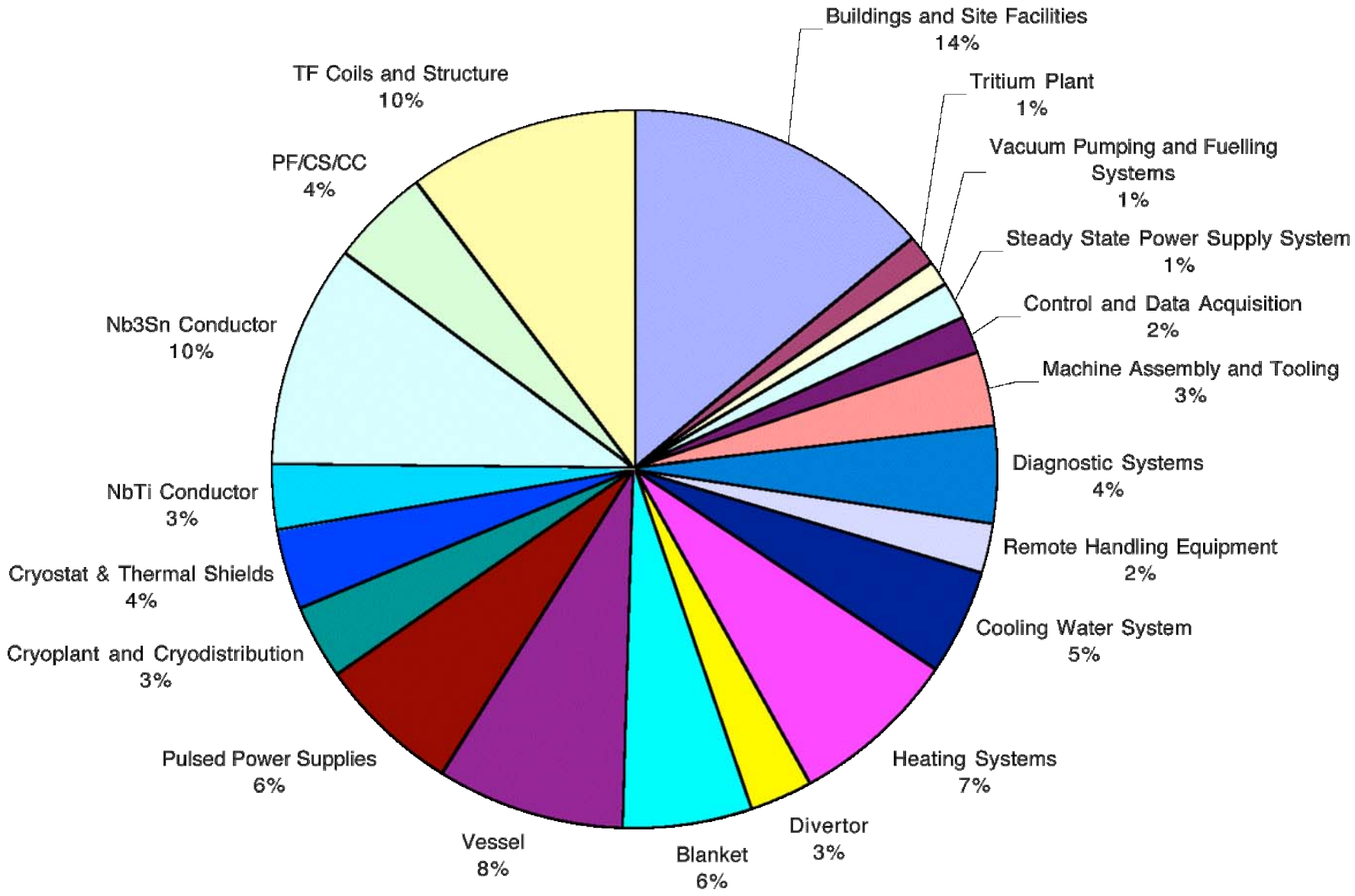
ITER Team evaluated work-quantities and rates to derive "value"

ITER Team

Negotiators adopted "values" as the basis for Negotiations



Direct Capital "Value"



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Heating / Current Drive	7%	$??M / $??M	None - High?	?%/ ?%/... total=?%	?%
Diagnostics and CODAC	7%	$??M / $??M	Medium - High?	?%/ ?%/... total=?%	?%
	100%	$??M / $??M		?%/ ?%/...; total= ?%	total=?% $???M / $???M

We are beginning cost-estimates for the "most-desirable" in-kind contributions

- **Desired deliverables and dates for US expressions of interest**
  - early assessments and estimates for most-desirable systems for April NSSG meetings
  - refined and extended estimates for May N-9 and P-1 meetings
- **To provide timely inputs to the Negotiators on US costs, two activities are underway:**
  - (1) adaptation of the ITER-Team's Evaluated Costs for the "most desirable packages" to the US environment (to support the April NSSG meetings)
  - (2) development of industrial (preferred) and laboratory/university estimates based on ITER Procurement Packages (to support N-9 and P-1 meetings and beyond)

(1) adaptation of the ITER-Team's Evaluated Costs

- **to match available time and resources in the near term, we have narrowed the focus for the initial estimates to the most desirable systems, based on FESAC BP Strategy priorities and US experience during the EDA:**
  - diagnostics
  - ICRF/EC/fueling
  - CS magnet
  - divertor

- **the results will provide benchmarks comparing ITER "value" with US cost-estimates, which may be applicable to a broader range of systems**

- **Contingency, supporting program, etc., will be estimated**

- **Two processes are being used...**
  - (a) incorporating US rates
  - (b) expert assessment

1.a. Incorporating US rates

Component or Process	work-quantity	$/work-quantity	Cost
component A	? units (lbs, man-years, ...)	$? / unit	$?
component B	? units (lbs, man-years, ...)	$? / unit	$?
process A	? units (lbs, man-years, ...)	$? / unit	$?
process B	? units (lbs, man-years, ...)	$? / unit	$?
Sub-total			$?

- Since the work-quantities are likely more accurate, the focus is on using US rates to adapt the estimate to the US

1.b. Expert assessment

- **US experts are studying and analyzing the ITER Cost Estimates and preparing**
  - findings and
  - recommendations on appropriate contingency

Major area	ITER Value (kIUA->$)	US coordinators
Diagnostics	$169M.	Young/Johnson (PPPL)
Vacuum Pumping and Fueling System	$4M	Gouge (ORNL)
Ion Cyclotron H&CD	$46M	Swain (ORNL) / Hosea (PPPL)
Electron Cyclotron H&CD	$111M	Temkin (MIT) / Hosea (PPPL)
Magnet Systems - Central Solenoid and associated strand	$174M	Minervini (MIT)
Divertor	$109M	Ulrickson (SNL)
TOTAL	$613M	

(2) developing industrial (preferred) and laboratory/university estimates

- **Area Coordinators have developed approaches to the bottom's-up estimation of costs of the most desirable procurement packages**
  - using ITER Procurement Packages which include functional requirements, detailed designs, specifications, interfaces, split of responsibilities between supplier and customer, and QA arrangements
  - estimating the work-quantities based on ITER Procurement Package
  - determining the rates for the work
  - providing supporting data and detailed descriptions of potential deliverables and processes, in the format of the ITER Cost Estimation Workbooks
  - (+ area coordinators' estimation of the scope and cost of the US Supporting Program)

- **Scopes of work on "most desirable scope" for the cost-estimation activity are nearly complete**

- **Selection of the industrial supplier for the cost estimates will be either:**
  - competitive, with selection by explicit evaluation criteria
  - non-competitive, with approved justification for non-competitive procurement

- **Schedule: procurement actions in March; deliverables May-July**

Reference: ITER Evaluated Cost Estimate
1 kIUA = $1.436M (grand total = $3955M and $370M)

Procurement Package			Direct Capital Cost (1) (kIUA)	Spares deferred Investment (2) (kIUA)
	No.			
Magnetic Systems	1	Toroidal Field Coils Windings	117	4
	2	Magnet Structures	168.3	5.4
	3	Poloidal Field Coil & Correction Coils	49.7	0
	4	Central Solenoid Coil	31.1	3.4
	5	Feeders	41	3.2
	6	Conductor	355	24.2
		Subtotal	**762.1**	**40.2**
Vacuum Vessel	1	Main Vessel	155	0
	2	Port Assemblies	75	0
		Subtotal	**230**	**0**
Blanket System	1	Blanket Manifolds, Filter Shields	6	0
	2-1	FW/Blanket Shield Modules	142.6	7.3
	2-2	Port Limiters	6.1	1.3
	3	Blanket Module Connections	10.5	0
		Subtotal	**165.2**	**8.6**
Divertor	1	Cassette Integration & Testing	10.7	0.5
	2	Plasma Facing Components	65.3	6.4
		Subtotal	76	6.9
Machine Assembly	1	Assembly Operations	50.3	
	2	Assembly Tooling	42.4	0
		Subtotal	**92.7**	**0**
Cryostat	1	Cryostat & VV Pressure Suppr. System	75.8	0
Thermal Shields	1	Thermal Shield System	28.8	0
Vacuum Pumping & Fueling System	1	Non-standard Cryopumps & Related Equipment	8.9	2.3
	2	Roughing Pump Sets & Change-over Boxes	6.7	0
	3	Leak Detection Stations	5	0
	4	Standard Components	5.3	0
	5	Pellet Injector	2.5	2.5
	6	Gas Injector Vlave Boxes	4.3	1.3
	7	GDC Conditioning System	1.5	0.6
		Subtotal	**34.2**	**6.8**
Machine Core		Subtotal	1464.8	62.5

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R/H Equipment		Blanket RH Equipment	27.1	0.8
		In-Vessel Div. Maintenance Equipment	11.7	0.3
		Transfer Cask System	10	6.4
		viewing/Metrology Systems	6	0.8
		Neutral Beam RH Equipment	0.6	5.4
		Hot Cell Repair/Maintenance Equipment	5.7	38.6
		Subtotal	**61.1**	**52.3**
Cooling Water	1	PHTS and CVCS	71	2.6
	2	Heat Rejection System	37.4	10.8
	3	Component Cooling & CW Systems	23.1	3.4
		Subtotal	**131.5**	**16.8**
Tritium Plant	1	Tokamak Exhaust Processing System	6.1	6.9
	2	Storage & Delivery, Long-Term Storage System	11.9	2.6
	3	HTD Isotope Separation	0	6.2
	4	Atmosphere Detritiation	12.8	17.4
	5	Water Detritiation	3.7	10.8
	6	Tritium Plant Analytical System	1	0.6
	7	Tritium Plant Automatic Control System	1.1	0.8
		Subtotal	**36.6**	**45.2**
Cryodistribution		Cryoplant	60.5	2.5
		Cryolines	12.2	4
		Cryodistribution Components	16.2	1.4
		Subtotal	**88.9**	**7.9**
Power Supplies & Distribution	1	High Voltage Substation and AC Distribution System	26.6	
	2	AC/DC Converters, Reactive Power compensators and Harmonic Filters	81.2	
	3	Switching Networks, Discharge Circuits, DC Distribution and Instrumentation	67.2	
		Subtotal	**175**	**3.2**
	8	Steady State Electrical Power Network		
		Subtotal	**39.7**	**0.3**
Buildings	1	Reinforced Concrete and Site Infrastructure Elements	311.5	
	2	Steel Frame Buildings	68.8	
		Subtotal	**380.3**	**12**
Waste Treatment and Storage	1	Waste Treatment and Storage	2.1	7
Radiological Protection	1	Radiological Protection	1	3.2
Auxiliaries		**Subtotal**	**916.2**	**148**

Reference: ITER Evaluated Cost Estimate
1 kIUA = $1.436M (grand total = $3955M and $370M)

IC H&CD	1	Antenna Arrays and Vacuum Transm. Lines	4.5	0
	2	Main Transm. Line and Matching System	4.8	0
	3	RF Power Sources & RF Monitoring Control	16	2
	4	Power Supply	6.9	0
		Subtotal	**32.2**	**2**
EC H&CD	1A	Equatorial Launcher	7.3	0
	1B	Upper Launcher	8.9	0
	2	Transmission Line	17.9	0
	3	RF Power Sources and Controls	29.5	3
	4	Power Supply	13.9	0
		Subtotal	**77.5**	**3**
NB H&CD	1	Assembly and Testing	3.8	0
	2	Beam Source and High voltage Bushing	9.5	0
	3	Beamline Components	3.9	0
	4	Presssure/Vacuum Vessels, Drift Duct and Passive Magnetic Shielding	11.9	0
	5a	Active Corr./Compensation Coils	4.4	0
	6	Power Supply	62.5	0
		Subtotal	**96**	**0.2**
H and CD		73MW (100MW in 1998)	205.7	5.2

Reference: ITER Evaluated Cost Estimate
1 kIUA = $1.436M (grand total = $3955M and $370M)

Diagnostics	A	Diagnostics Magnetics	3.3	0
	B	Neutron Systems	3.9	6.2
	C	Optical Systems	16.9	8.8
	D	Bolometry	6.7	0
	E	Spectroscopic Systems	8.9	13.6
	F	Microwave Systems	8.3	9.4
	G	Operational Systems	11	0
	N	Standard Diagnostics	36.3	4.2
		Diagnostic Neutral Beam:Line	13	0.1
		Diagnostic Neutral Beam:Power Supply	9.7	0
		Subtotal	**118**	**42.3**
CODAC		Hardware and Software (rough estimate	50	0

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Diagnostics and CODAC	7%	$??M / $??M	Medium - High?	?%/ ?%/... total=?%	?%
	100%	$??M / $??M		?%/ ?%/...; total= ?%	total=?% $???M / $???M

US Interest in ITER Procurement Packages

- **FESAC provided significant guidance in the Burning Plasma Strategy Report (September 2002)**
  - prioritized US objectives (section V and Appendix C.4)
  - minimum roles and opportunities (section V and Appendix C.4.1)
  - guidelines and principles for assessing potential roles (Appendix C.2)
  - priorities for US contributions to the ITER Project (Appendix C.4.1)

Prioritized U.S. objectives for U.S. participation in ITER (from FESAC BPS, 9/2002)

(O1) to perform research on burning plasmas in the tokamak configuration, to contribute to the science base for the full range of toroidal confinement configurations;

(O2) to develop enabling technology that supports the burning plasma research and positions the U.S. to more effectively pursue burning plasma research;

(O3) to advance fusion energy technologies, to contribute to the technology base necessary for a demonstration fusion power plant; and

(O4) to increase involvement of U.S. industry in the fusion program, both in design and fabrication of components for burning plasma experiments and in preparation for U.S. design and construction of a demonstration fusion power plant.

Minimum roles and opportunities (from FESAC BPS, 9/2002)

(a) a significant U.S. role in the decision-making regarding the ITER research program, including overall research directions and selection of experiments;

(b) opportunities for U.S. researchers from all segments of the U.S. fusion community (universities, laboratories, and industry) to propose, plan, conduct and participate in experiments as members of the ITER research team;

(c) opportunities for U.S. researchers to play leadership roles and participate in ITER's topical task forces, with access to all data from all available systems for all ITER experiments;

(d) opportunities to apply theory and integrated modeling in design and analysis of experiments and in benchmarking of models against ITER data;

(e) opportunities for the U.S. to develop and contribute equipment during the construction and operations phases of the device, and to have access to engineering data equal to that of all partners;

(f) opportunities to propose/develop/design/fabricate/install/operate advanced diagnostics and enabling technology (e.g., plasma control tools) beyond the baseline; and

(g) opportunities to participate in fusion energy technology activities such as the development and testing of blanket modules.

Guidelines and principles for assessing potential roles (from FESAC BPS, 9/2002)

- **criteria for U.S. participation in construction:**
  - building on U.S. experience, strength, and/or leadership;
  - maintaining/increasing the breadth and depth of U.S. capability in fusion related technologies; and
  - increasing U.S. industrial capacity in high-tech areas, especially ones important to fusion.
  - confidence to complete task(s) within the allocated U.S. budget.

- **criteria for programmatic or operational activities:**
  - providing opportunity to study burning plasma science under reactor-relevant conditions;
  - advancing fusion science or technology in areas important to the U.S.;
  - providing scientific experience relevant to other magnetic configurations;
  - building on U.S. scientific strengths and providing synergy/continuity with existing U.S. facilities; and
  - broadening U.S. expertise by providing opportunities not available on existing U.S. facilities.

Priorities for US Contributions to the ITER Project (from FESAC BPS, 9/2002)

- The highest priority should go to contributions that enable research on burning plasmas, research on burning plasmas and enabling technology (O1 and O2). This scope would include areas such as baseline diagnostics, plasma control, remote research tools, etc.

- Second priority should go to fusion technologies (O3), particularly those in which the U.S. has special experience and interest and where U.S. industry could have a significant role (O4). This scope would include fusion-relevant products such as superconducting magnets, plasma-facing components, etc.

- Third priority should go to high-tech non-fusion scope, such as more conventional technical industrial scope. Included would be power supplies, control and data acquisition, superconducting strand, etc.

Starting points for discussion: Diagnostics and CODAC (1 of 1)

Procurement Package			Direct Capital Cost	Spares deferred Invest-ment	Level of US interest (high, medium, low, none)
			(kIUA)	(kIUA)	
	No.				
Diagnostics	A	Diagnostics Magnetics	3.3	0	High
	B	Neutron Systems	3.9	6.2	High
	C	Optical Systems	16.9	8.8	High
	D	Bolometry	6.7	0	High
	E	Spectroscopic Systems	8.9	13.6	High
	F	Microwave Systems	8.3	9.4	High
	G	Operational Systems	11	0	High
	N	Standard Diagnostics	36.3	4.2	High
		Diagnostic Neutral Beam:Line	13	0.1	Medium
		Diagnostic Neutral Beam:Power Supply	9.7	0	Low
CODAC		Hardware and Software (rough estimate	50	0	Medium-High

Starting points for discussion: Heating and current drive (1 of 1)

Procurement Package			Direct Capital Cost	Spares deferred Invest-ment	Level of US interest (high, medium, low, none)
			(klUA)	(klUA)	
	No.				
IC H&CD	1	Antenna Arrays and Vacuum Transm. Lines	4.5	0	High
	2	Main Transm. Line and Matching System	4.8	0	High
	3	RF Power Sources & RF Monitoring Control	16	2	Medium
	4	Power Supply	6.9	0	Medium
EC H&CD	1A	Equatorial Launcher	7.3	0	High
	1B	Upper Launcher	8.9	0	High
	2	Transmission Line	17.9	0	High
	3	RF Power Sources and Controls	29.5	3	High
	4	Power Supply	13.9	0	Medium
NB H&CD	1	Assembly and Testing	3.8	0	None
	2	Beam Source and High voltage Bushing	9.5	0	None
	3	Beamline Components	3.9	0	None
	4	Presssure/Vacuum Vessels, Drift Duct and Passive Magnetic Shielding	11.9	0	None
	5a	Active Corr./Compensation Coils	4.4	0	None
	6	Power Supply	62.5	0	None

Starting points for discussion: Machine Core (1 of 2)

Procurement Package			Direct Capital Cost	Spares deferred Invest-ment	Level of US interest (high, medium, low, none)
			(klUA)	(klUA)	
	No.				
Magnetic Systems	1	Toroidal Field Coils Windings	117	4	Medium
	2	Magnet Structures	168.3	5.4	Low
	3	Poloidal Field Coil & Correction Coils	49.7	0	Medium
	4	Central Solenoid Coil	31.1	3.4	High
	5	Feeders	41	3.2	Medium
	6	Conductor	355	24.2	High
Vacuum Vessel	1	Main Vessel	155	0	Low
	2	Port Assemblies	75	0	Low
Blanket System	1	Blanket Manifolds, Filter Shields	6	0	Low
	2-1	FW/Blanket Shield Modules	142.6	7.3	Medium
	2-2	Port Limiters	6.1	1.3	Low
	3	Blanket Module Connections	10.5	0	Low

Starting points for discussion: Machine Core (2 of 2)

Procurement Package			Direct Capital Cost	Spares deferred Invest-ment	Level of US interest (high, medium, low, none)
			(kIUA)	(kIUA)	
	No.				
Divertor	1	Cassette Integration & Testing	10.7	0.5	Medium
	2	Plasma Facing Components	65.3	6.4	High
Machine Assembly	1	Assembly Operations	50.3		None
	2	Assembly Tooling	42.4	0	None
Cryostat	1	Cryostat & VV Pressure Suppr. System	75.8	0	Low
Thermal Shields	1	Thermal Shield System	28.8	0	Low
Vacuum Pumping & Fueling System	1	Non-standard Cryopumps & Related Equipment	8.9	2.3	Medium
	2	Roughing Pump Sets & Change-over Boxes	6.7	0	Low
	3	Leak Detection Stations	5	0	Low
	4	Standard Components	5.3	0	Low
	5	Pellet Injector	2.5	2.5	High
	6	Gas Injector Valve Boxes	4.3	1.3	Low
	7	GDC Conditioning System	1.5	0.6	Low

Starting points for discussion: Auxiliaries (1 of 2)

Procurement Package			Direct Capital Cost	Spares deferred Invest-ment	Level of US interest (high, medium, low, none)
			(kIUA)	(kIUA)	
	No.				
R/H Equipment		Blanket RH Equipment	27.1	0.8	Medium
		In-Vessel Div. Maintenance Equipment	11.7	0.3	Medium
		Transfer Cask System	10	6.4	Low
		viewing/Metrology Systems	6	0.8	Medium
		Neutral Beam RH Equipment	0.6	5.4	Low
		Hot Cell Repair/Maintenance Equipment	5.7	38.6	Low
Cooling Water	1	PHTS and CVCS	71	2.6	Low
	2	Heat Rejection System	37.4	10.8	None
	3	Component Cooling & CW Systems	23.1	3.4	Low
Tritium Plant	1	Tokamak Exhaust Processing System	6.1	6.9	Medium
	2	Storage & Delivery, Long-Term Storage System	11.9	2.6	Medium
	3	HTD Isotope Separation	0	6.2	Medium
	4	Atmosphere Detritiation	12.8	17.4	Medium
	5	Water Detritiation	3.7	10.8	Medium
	6	Tritium Plant Analytical System	1	0.6	Medium
	7	Tritium Plant Automatic Control System	1.1	0.8	Medium

Starting points for discussion: Auxiliaries (2 of 2)

Procurement Package			Direct Capital Cost	Spares deferred Invest-ment	Level of US interest (high, medium, low, none)
			(kIUA)	(kIUA)	
	No.				
Cryodistribution		Cryoplant	60.5	2.5	None
		Cryolines	12.2	4	None
		Cryodistribution Components	16.2	1.4	None
Power Supplies & Distribution	1	High Voltage Substation and AC Distribution System	26.6		Low
	2	AC/DC Converters, Reactive Power compensators and Harmonic Filters	81.2		Low
	3	Switching Networks, Discharge Circuits, DC Distribution and Instrumentation	67.2		Low
	8	Steady State Electrical Power Network			None
Buildings	1	Reinforced Concrete and Site Infrastructure Elements	311.5		None
	2	Steel Frame Buildings	68.8		None
Waste Treatment and Storage	1	Waste Treatment and Storage	2.1	7	None
Radiological Protection	1	Radiological Protection	1	3.2	None

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Auxiliaries	35%	$??M / $??M	None - Medium?	?%/ ?%/... total=?%	?%
Heating / Current Drive	7%	$??M / $??M	None - High?	?%/ ?%/... total=?%	?%
Diagnostics and CODAC	7%	$??M / $??M	Medium - High?	?%/ ?%/... total=?%	?%
	100%	$??M / $??M		?%/ ?%/...; total= ?%	total=?% $???M / $???M

Summary on Interests in "In-Kind" contributions (costing and interests)

- **Discussion of "Allocations of Procurements" is underway.**
  Other parties have expressed their interests.
  The US has been invited to provide its initial expressions of interest by April 1.

- **"Cost" and "interest" information, is needed to enable the process of exploratory discussions.**
  Subsequent iterations will be permit refinements.

- **It is expected that other parties are interested in areas similar to our's....**

- **The US Negotiators will benefit from US community efforts to**
  - refine the US costs for packages that might be offered
  - clarify underlying "interests" of the US and other parties (in-kind contributions, roles, management, ...), and
  - devise options to meet interests of all parties, finding ways to maximize joint gains

- **FESAC is invited to suggest refinements of the cost-estimation activity and "strawman" levels of interest....**
  The Burning Plasma PAC will be immediately engaged in the processes.