Compilation of all STCC contributions to the development of an ST R&D Strategic Plan, Started 3/5/08, Martin Peng

Bill Dorland (BD)
Don Hillis (DH)
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Fred Levinton (FL)
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1. Mission statement – Why do we exist?
2. Vision statement – Where do we want to be in 5, 10, 15 years?
3. SWOT – What are our strengths, weaknesses, opportunities, and threats?
4. Competitive advantage – What are we best at?
5. Strategic Objectives – What are the key activities we need to perform (*and the anticipated results?*) to achieve our vision?
6. Strategies – How do we achieve our objectives?
7. Short-term goals/priorities/initiatives – What are our 1, 3, 5 year goals to achieve our strategic objectives?
8. Action Items / Plans – Specific plans to implement our goals
9. Scorecard – Key performance measures to track our progress towards realizing our vision
10. Financial assessment

0. Developing new ST strategic plan – what ideas should be included? Also, conference call / meeting minutes.	Notes
MP 080406: Dear STCC, Here are my notes for the 080404 conference call. Please comment if you desire. Thanks for another very good conference call. An updated schedule for the ST strategic planning based on the STCC progress is also attached for reference. Look forward to receiving next week emails from all members on the agreed actions items. Thanks in advance. Present: DM, AS, FL, RLH, DH, MP Introduction - STCC agreed to use the time period 3:30-5:00pm Fridays for conference calls agreed by the committee. Tentative call schedules are shown in the draft STCC schedule: ST-Strategy-schedule-080403. - Agenda of call: 1) Vision Statement, 2) SWOT development - MP: NCSX escalation a worrisome development - MP: was asked to serve on the FESAC panel on magnetic alternates; will work with STCC in this participation in this panel; Dave Hill asked to serve as chair. Vision statement - AS explained his draft for STCC discussion; aimed to define a long term vision for the ITER era; explained that the "5, 10, 15 year vision" meant to be "5, 10, or 15 year vision". - STCC agreed to choose the longer term option to fit the ITER era; shorter term more appropriate as "5. Strategic Objectives." - DM suggested including reactor relevance. - FL suggested tying to reactor relevant issues even at the 5 and 10 year vision (strategic objectives) levels. Agreed to 20 year vision statement, then the nearer term steps Single vision statement	Here

- Action AS to send out revised version - MP: Q=10 may be too restrictive - RLH: suggested considerations of options other than ITER (FDF, CTF, NHTX, for example). Longer term view and shorter term views may turn out to be different. - AS: future outcome is uncertain, in view of ITER uncertainty in the near term. - RLH: need to distinguish between what should happen vs. what could or might; agreed to R Fonck's position that the fusion strategic plan should establish mission and vision that have last value and can survive short term uncertainties and set-backs. - FL 30 year development plan (RG panel) contains examples of the time scale for component testing (or for some such facilities). SWOT - DM: how long will we make the lists in each component of SWOT: - MP: very good starting inputs from DM, AS, MP, JM so far. Recommend all members to introduce own ideas of SWOT based on individual perspectives of the STCC ST R&D components. Agreed Actions - AS to issue updated draft of vision statement based on comments received - All STCC members add own ideas to SWOT by mid-next-week, so that an all inclusive collection of ideas for SWOT can be compiled by chair by 080411 for review and comment during STCC conference call.	
MP 080319: Dear STCC Colleagues, Thanks to many for agreeing to the time of tomorrow's conference call. I would like to suggest the following agenda: 1) Steve Eckstrand – comments and discussion of work assignment on ST strategic plan and support of FES strategic planning (20 min) 2) Schedule for producing first draft of ST strategic plan in anticipation of FESAC panel efforts and mini-Snowmass workshops (15 min) 3) Brainstorming on the elements of strategic plan and their content (45 min) 4) Action items (10 min) We should try to adjourn at 5PM. We will go around the table for each item to identify ideas and results. Please email you input and ideas ahead of the conference call. I will email before the conference call a compilation of relevant exchanged ideas as reference information to help the discussion. Thanks and best regards,	
MP 080317: This is a good start from Jon and Dick regarding the ST strategic plan. To help enable effective use of our time on this very complex enterprise of the STCC, I request that the "standard elements of strategic planning" be used to organize our ideas and discussions: 1. Mission statement – Why do we exist? 2. Vision statement – Where do we want to be in 5, 10, 15 years?	

3. SWOT – What are our strengths, weaknesses, opportunities, and threats? 4. Competitive advantage – What are we best at? 5. Strategic Objectives – What are the key activities we need to perform to achieve our vision? 6. Strategies – How do we achieve our objectives? 7. Short-term goals/priorities/initiatives – What are our 1, 3, 5 year goals to achieve our strategic objectives? 8. Action Items / Plans – Specific plans to implement our goals 9. Scorecard – Key performance measures to track our progress towards realizing our vision 10. Financial assessment I have started to compile all informative emails on our ST strategic planning into this growing table of ideas, by putting them in this hierarchy of planning elements, so that whenever a major decision is to be made by the STCC, all inputs up to that point are available to the STCC in an effective manner. Please take quick look at the attached compilation up to now since the work leading to the mission statement, and let me know of additional information that needs to be included. Regarding the planning elements above, using the example of JM 080312's ideas of item a): "possible upgrades and next-steps for U.S. ST program in support of ST's abroad" addresses "6. Strategies". "what scientific issues/themes will this program address?" addresses "5. Strategic objectives". "all ideas broader than NHTX and CTF" addresses "2. Vision statement" for 5, 10, and 15 years. For JM's b): "What is really needed to move on – with high confidence – to the above next-step STs" addresses "5. Strategic Objectives". "what research is needed" addresses "6. Strategies". "Future design benefit" addresses "3. SWOT". In view of the strong desire by some of us to try to maintain NSTX beyond 2-3 years, I suggest what we should consider at least two scenarios as we introduce ideas for each element of the ST Strategic Planning: A) NSTX complete its mission in 2-3 years, and B) NSTX continues research on remaining critical topics beyond 2-3 years. Please suggest additional scenarios that we should address. Please, when you contribute ideas to this strategic planning process, indicate which scenario is addressed.	
DM 080312: I do not see how Rich could put anything else down in the facilities review, in response to OFES direction. Let's move on here. I would also like to see the STCC begin to consider Jon's two suggested lines of discussion: > a) what is the menu of possible upgrades and next-steps for U.S. ST program and in support of ST's abroad. What scientific issues/themes will this program address? I think this discussion should be broader than NHTX and CTF missions so all ideas are put on the table.	

> > b) What is really needed to move on - with high confidence - to above next-step STs, with a view longer than 3 years, since we all believe such considerations should determine what research is needed, rather than purely political/financial considerations. Future design benefit should be part of this equation.	
JM 080312: All of this is consistent with option discussed at beginning of last NSTX research forum and Fonck's Feb. FESAC talk, i.e. FY10 being final year of operation of NSTX, FY11 being a transition year (write up papers, etc), and FY12 the first year of full NCSX operation. While the above is the default position of PPPL and OFES, and at present is presented as the most likely outcome (and it may very well be), it's not over til it's over: a) Decision to re-baseline NCSX is not guaranteed b) Schedule for NCSX in out years could slip (gasp) c) NSTX has been asked to submit a 5 year plan. We have to submit plan for FY09 and 10 in any case, and will also give a plan for out-years (FY11-13) On NSTX, we have to plan for all contingencies (some more probable than others) ranging from: a) 10% cut and final ops in FY09, to b) termination of NCSX and large increases in NSTX budget (full utilization) So, uncertainty is the only certainty. The STCC has done a good job in being responsive to OFES, but I think we need to do more to define: a) what is the menu of possible upgrades and next-steps for U.S. ST program and in support of ST's abroad. What scientific issues/themes will this program address? I think this discussion should be broader than NHTX and CTF missions so all ideas are put on the table. b) What is really needed to move on - with high confidence - to above next-step STs, with a view longer than 3 years, since we all believe such considerations should determine what research is needed, rather than purely political/financial considerations. Future design benefit should be part of this equation. My $0.02	MP: During a lunch discussion among JM, DH, and MP, on the issues facing the future of the ST program in U.S., and some of our perceptions, it was agreed that we should have a conference call on Wednesday-Thursday next week to consolidate the ideas of how to develop the new ST strategic plan. This email from JM followed up with this lunch discussion. MP: DM and SAS emailed support of considering a) and b).
1. Mission statement – Why do we exist? ST Mission for the ITER era: Develop compact, high-beta ST burning plasma capability for use-inspired R&D.	
MP 080317:	

In anticipation of the upcoming conference call this Thursday, I suggest the considerations of the following questions relating to the mission statement for the ITER era that we arrived at for the BPM presentation: ST Mission for the ITER era: Develop compact, high-beta ST burning plasma capability for use-inspired research and development. I suggest that we answer the following questions to firm up what we mean by this mission statement: 1) What is ST? 2) What is compact? 3) What is high-beta? 4) What is compact, high-beta ST? 5) What is burning plasma capability? 6) What is "use-inspired" R&D? 7) How should this use-inspired R&D relate to the knowledge base gaps identified by the FESAC (Greenwald) Planning Panel? I assume that the ITER era = 20 years. Are there different opinions regarding this assumption? If so please raise them for STCC discussion. Also Rob Goldston suggested on 3/7/08 dropping "burning plasma" in the mission statement. Should STCC discuss this suggestion and come up with a consensus response?	
DB 080308 Hi Steve, Don Stokes was the Dean of the Woodrow Wilson School of Public Policy at Princeton before he died of leukemia. He was very interested in science policy, and popularized the expression "use-inspired" in a book about "Pasteur's Quadrant." I have attached a power-point presentation that I found on the web by googling "use-inspired".	MP: excerpted from email from BD to SAS.
Statement arrived at following dry run with the STCC prior to the BPM: 3/6/08: Mission: Develop compact, high-beta ST burning plasma capability for use-inspired research and development.	
Working draft arrived at on 3/5/08: Mission: Develop an ST-based burning plasma capability for use-inspired engineering and nuclear sciences R&D and beyond.	
MP 3/5/08: Great to start discussion on the visions, etc. of the ST Program, providing motivations to move toward. Note that Ray Fonck's slide #4 says:	

Classical Elements of a Strategic Plan • Mission statement – Why do we exist? • Vision statement – Where do we want to be in 5, 10, 15 years? • SWOT – What are our strengths, weaknesses, opportunities, and threats? • Competitive advantage – What are we best at? • Strategic Objectives – What are the key activities we need to perform to achieve our vision? • Strategies – How do we achieve our objectives? • Short-term goals/priorities/initiatives – What are our 1,3,5 year goals to achieve our strategic objectives? • Action Items / Plans – Specific plans to implement our goals • Scorecard – Key performance measures to track our progress towards realizing our vision • Financial assessment So, I will collect all the inputs on these and try to put them in the right areas, so that there is an up to date compilation of them from everyone, to support efficient progress in discussion/debates. I look forward to all's contribution in this direction. Martin P.S. you might want to look at the latest draft mission statement that accounts for all the relevant considerations listed in the email that crossed paths with yours in real time.	
MP 3/5/08: Aaron, and all, This is excellent discussion. Thanks. So, we arrived at the following options (assuming I am up to date in the emails received, including earlier comments by Steve): - Shortest version from Aaron: Mission: Develop and (an) ST-based confinement concept for low-risk fusion nuclear science tests and beyond. - Shorter version derived from Aaron's earlier draft: Mission: Realize a compact ST-based, driven burning plasma facility of lowered risk and cost that enables effective use-inspired R&D to establish the remaining engineering and nuclear science knowledge-base needed by Demo. - Just received Jon's example: "Leverage the simplicity, compactness, and high beta of the ST configuration to accelerate the path to DEMO." - Aaron's question is to the point: where do we want to be when ITER achieves Q ~ 10, which is likely to be in ~20 years? - He also provided great examples: "To enable people and businesses throughout the world to realize their full potential."—Microsoft "Organize the world's information and make it universally accessible and useful."—Google So, shorter statements would be better than longer ones. - He further warned, correctly, that we may be overlapping the mission statement with the vision statements we have started to draft. - Noting that good mission statements use only words of: action, object of the action (what is acted on or beneficiaries), and result, with clarity and without descriptors. - Further, not forgetting the DOE guidelines:	About 50 emails were exchanged among STCC members, with rather divergent views. Followed Aaron's recommendation on a very short statement that covers only action, object, and result, while leaving details to subsequent components of the strategic plan. This email tried to account for all input and integrate all boundary conditions to arrive at a working mission statement for the BPM on 2/11-12/08.

1) Limiting the overall time scale to the ITER era, currently assumed to be equivalent to ~20 years, and 2) Identifying and justify a mission that, at minimum, is a burning plasma or beyond. - Still further: Use the information from the Greenwald panel report, which has identified a broad range of gaps to fill, among which we are focusing primarily on Themes B and C. Are there other objective considerations of factors that should be included here. So, these have been suggested: Action: - develop, - realize/enable, - leverage/accelerate What is acted on and/or beneficiaries: - ST-based confinement concept; - a compact ST-based, driven burning plasma facility of lowered risk and cost; - the simplicity, compactness, and high beta of the ST configuration Result: - for low-risk fusion nuclear science tests and beyond; - effective use-inspired R&D to establish the remaining engineering and nuclear science knowledge-base needed by Demo; - the path to DEMO My present choice, accounting for the above and assuming that these are inclusive elements of consideration, would be: Action: Develop Object: an ST-based burning plasma capability Result: for use-inspired engineering and nuclear sciences R&D needed by Demo. Mission: Develop an ST-based burning plasma capability for use-inspired engineering and nuclear sciences R&D needed by Demo. Reasoning: - "Develop" appears to be better than "realize", as the latter will depend also on factors beyond the OFES funded efforts. - our time frame is about 20 years, which appears not as long as the Microsoft and Google mission time-scales. - it needs to be adequately specific to drive focus of nearer term visions. The alternatives (concept or the attractive features) appear to potentially lead to extensive proliferation of nearer term research and much broader 5-year, 10-year, and 15-year visions. - the result we can aim for is to carry out the needed R&D as identified by Greenwald panel (use-inspired engineering and nuclear sciences R&D), and not the successful establishment of the needed knowledge base. - the statement is adequately short and clear, and adequately challenging and provocative.	

Again, thanks to all, and Aaron in particular, for making this process of discussion effective, covering a wide range of views and ideas, to arrive at something that can be very good. I plan to use this in the draft BPM presentation for further comments in the context.	
AS 3/5/08: My final comment on this for today (I have to get some other work done occasionally) is that I am leery of using DEMO in the mission statement. DEMO doesn't exist and is ill defined at best, so I would prefer a more general goal.	
MP 3/5/08: Good point. How about: Mission: "Develop an ST-based burning plasma capability for use-inspired fusion engineering and nuclear sciences R&D and beyond."?	
2. Vision statement – Where do we want to be in 5, 10, 15 years?	
MP 080405: Dear Aaron, This draft contains the improvements suggested during the conference call yesterday, and contains a very strong message. How about the following suggestions, which does not change the intended message, for consideration by the STCC? - Change "majority alpha heating" to "burning plasma": this avoids making any inference on ITER achieving even Q>5, as it is not a necessary point for the purpose of the vision statement. - Indeed "reactor-grade" will require some explanation that may add length, and potentially lead to a discussion of "fusion reactors" not preferred by OMB. How about changing "sufficient plasma performance in a reactor-grade environment" to "sustained environment"? Sustained environment to provide "the presence of very high neutron fluences" and "a reactor environment" specified in Themes B and C, respectively, of the GW Panel report, and implies a burning plasma. It is again not necessary to specify the degree of plasma burning for the purpose of vision statement. - Change "resolve the outstanding nuclear science issues" to "establish the knowledge base": this links more directly to the "use-inspired R&D" of the mission statement. - Change "hindering the development of economical fusion power reactors" to "needed to implement fusion power": This echoes the idea that fusion power implementation will require a separate government decision in the future, and that this decision will require the knowledge base articulated in the GW report. The ST Program vision to enable the R&D to establish that knowledge base. Pulling these together, we would arrive at the following (also shortened where appropriate) draft: As ITER achieves plasma burn, the ST Program should deliver a sustained environment with high neutron fluences and heat fluxes for R&D to establish the nuclear science knowledge base needed to implement fusion power. Does this adequately support the present working mission statement, which is: "Develop compact, high-beta ST burning	

plasma capability for use-inspired R&D."? I look forward to learning comments by you and others. Thanks for quick action. Martin	
AS 080404: Dear STCC, After the STCC conference call on 4/4/08, I was charged with revising my draft ST vision statement. Here is my revised version: By the time that ITER achieves majority alpha heating, the ST program should achieve operation of a facility with sufficient plasma performance in a reactor-grade environment to generate the neutron fluence and heat flux required to resolve the outstanding nuclear science issues hindering the development of economical fusion power reactors. This statement is fairly neutral on the idea of an ST reactor. I think that is appropriate given the timescale and the constraint that we stay realistic. I also avoided the specific mention of Q = 10 performance on ITER, so if anyone has a more desirable ITER milestone to use to set the timescale, I'm quite open to suggestions. I think we should discuss what is meant by reactor-grade environment and possibly strengthen this. This phrase was meant to indicate that we should try to achieve plasma-wall interaction conditions (hot walls, coated in Li?, etc.) that are as close to DEMO as we can get while still maintaining the high plasma performance needed to achieve the high neutron fluence, etc. Comments? Regards, Aaron	
AS 080328: Hi Martin, et al., Here is what wikipedia has to say about crafting a vision statement (for what it's worth): The Vision describes a future identity and the Mission describes why it will be achieved. A Mission statement defines the purpose or broader goal for being in existence or in the business. It serves as an ongoing guide without time frame. The mission can remain the same for decades if crafted well. Vision is more specific in terms of objective and future state. Vision is related to some form of achievement if successful. Features of an effective vision statement may include: Clarity and lack of ambiguity	

Paint a vivid and clear picture, not ambiguous Describing a bright future (hope) Memorable and engaging expression Realistic aspirations, achievable Alignment with organizational values and culture, Rational Time bound if it talks of achieving any goal or objective With that in mind, here's my draft vision statement: By the time ITER reaches Q = 10, the ST program should achieve operation of a facility which generates sufficient neutron fluence and heat flux to address any remaining issues regarding the plasma-material interface and harnessing fusion power required for DEMO. The idea behind this vision statement is that ITER is going to address Theme A of the Greenwald report, so we need to try to address Themes B & C. Comments?	
DM 3/5/08: As far as statements of our vision for the ST are concerned, can we all please recognize that we have been taken out to the woodshed? We can claim to have been unfairly ambushed by NCSX, but the fact is, that it is NSTX, not C-mod or DIII-D, which will be shutdown as a consequence of the NCSX overrun. There are institutional punishment issues here, but if the ST truly were a compelling choice for fusion, then this would not be the case. 5 year vision: Consolidate as much as possible the physics basis for the ST through well-planned use of the remaining NSTX run time. Identify scientific gaps and promising areas for future progress. Move toward enhanced collaborations with MAST, and full utilization of the smaller U.S. ST facilities. 10 year vision: Through international collaborations, Pegasus, LTX, and an upgraded restart of NSTX, or alternatively a completely new facility, fill in the scientific gaps to form a complete picture of a compelling ST-based burning plasma facility. 15 year vision: Construction of the ST-based burning plasma facility. 20 year and beyond: Operations to establish the design basis for an ST-based DEMO.	Copied the visions also to Strategies
AS 3/4/08: No problems here. I am fine with this tuned up version of the mission statement. We're saying basically the same thing, so whatever wording works best for everyone is fine by me. Once we can agree on a mission (assuming the lack of response by the rest of the STCC means no major disagreement with this mission), then we should start to get into the much more difficult topic of coming up with a credible path to that goal. Looking at slide 4 of Ray Fonck's FESAC presentation (attached), we've come up with the first part of the ST strategic plan. Now we need to create a vision statement that identifies where we want to be at a specific point in time. Here is my quick first attempt at a vision statement: Over the next 5-10 years, answer the key scientific and technical questions which will allow for the creation of an ST-based burning plasma. I'm not sure if this time scale makes sense though. What do others think?	

I think the MOC work has us far along the path of the next steps of identifying our strategic objectives and identifying the strategies to achieve these objectives. Comments?	
MP 3/4/08: Thanks for the affirmative feedback on the mission statement (and for taking this to the next step according to Ray Fonck's slide. I like the direction of your 5-10 year vision, and agree with your assessment that the MOC work has advanced us far along the path to the next steps of identifying our strategic objectives and identifying the strategies to achieve these objectives. Let me offer some draft statements following your draft for yours and others' comments, referring to the simple mission statement: "The mission of the ST program in the ITER era is to realize an ST-based burning plasma facility of lowered risk and cost, that enables use-inspired R&D to establish the remaining engineering and nuclear science knowledge needed by Demo." 5 year vision: Commonality between ST and Tokamak fusion plasma science knowledge be broadly established in all FESAC-identified priority topical areas to enable realistic (low risk?) designs of this ST-based burning plasma facility. 10 year vision: Remaining plasma science knowledge for highly compact ST burning plasma devices, such as non-solenoidal start-up and ramp-up, be firmly established to ensure reliably operation of such a facility. 15 year vision: Hydrogen and deuterium operations of such a facility be started to verify all capabilities of such a facility before introduction of tritium fuel. 20 year vision: Burning plasma operation of such a facility be started to enable use-inspired R&D to establish the remaining engineering and nuclear science knowledge needed by Demo.	To include "low risk" here, a possible location would be in the 5-year vision, which is added in () for now.
AS 3/4/08: I think we have to keep this very short, clear and specific since we're trying to answer the question of "why do we exist" for the ST program for the next 20 years. I think more details should come into the vision statement and later on. Let's try a very short and sweet version. Mission: Develop and ST-based confinement concept for low-risk fusion nuclear science tests and beyond. The low-risk portion - meaning low physics risk - is essential. I'm defining low physics risk as meaning that it would require little to no extrapolation from current plasma physics knowledge. If we don't offer this benefit, then why not just build an AT? The nuclear science portion is important because that is the piece that is not being addressed by ITER. The beyond statement leaves open the possibility of going to a reactor, but I think we are going to face a lot of resistance if we try to sell the mission of the ST specifically as a DEMO/reactor concept at this point. I think DOE is going to have to clarify what they mean by burning plasma in this case. If they do hold us to the Q = 5 definition, then all of the alternates are in trouble.	
AS 3/4/08:	Low risk met with

I think we have to keep this very short, clear and specific since we're trying to answer the question of "why do we exist" for the ST program for the next 20 years. I think more details should come into the vision statement and later on. Let's try a very short and sweet version. Mission: Develop and ST-based confinement concept for low-risk fusion nuclear science tests and beyond. The low-risk portion - meaning low physics risk - is essential. I'm defining low physics risk as meaning that it would require little to no extrapolation from current plasma physics knowledge. If we don't offer this benefit, then why not just build an AT? The nuclear science portion is important because that is the piece that is not being addressed by ITER. The beyond statement leaves open the possibility of going to a reactor, but I think we are going to face a lot of resistance if we try to sell the mission of the ST specifically as a DEMO/reactor concept at this point. I think DOE is going to have to clarify what they mean by burning plasma in this case. If they do hold us to the Q = 5 definition, then all of the alternates are in trouble.	significant objections from SA. It could be included in Vision, for now.
3. SWOT – What are our strengths, weaknesses, opportunities, and threats?	
MP 080409: Dear STCC colleagues, In a discussion with Dave Hill (chair of Panel on Magnetic Alternates) yesterday, it became clear to me that ST will face strong scrutiny within the Panel. It is therefore high time for us to adjust our efforts and schedule to prepare inputs to inform the FESAC panel discussion. There is only about 3-month time for us to figure out what we need, obtain community input, formulate our input to the panel, prepare presentations and write-ups, as the ST strategic plan is drafted. It appears, I recon, that all community input must be concluded before end of July, so that the panel can prepare report during August for presentation to the entire FESAC in September for review and approval, before hopefully FESAC would submit the final report to Orbach by October 1. Note that the NSTX program and facility review is scheduled for the week of June 23, before which NSTX proposals will have to be finalized. How should the charges to the Panel be addressed in parallel with the development of the ST Strategic Plan? The attached table: FESAC charge vs Strategic Plan-080409 makes the link, and informs the updated working schedule: ST-Strategy-schedule-080409. The panel charge includes "identify and prioritize scientific and technical questions that need to be answered to achieve the specified goal." This topic is included in the schedule, together with a draft update of the MOCs (MOC-definitions-080409), adjusted to measure the criticality of these questions (not R&D topics as before). We should be prepared, if possible, also to review and approve these during the 080411 conference call. Any strong reactions? Martin	
MP 080407: Dear STCC, As the FESAC panel on magnetic alternates are being formed with a tight schedule to deliver its report by 10/1/08, I	

am motivated to anticipate how the STCC should prepare its community inputs to the panel. Note that a panel member will not be in a position to present such inputs in person. The attached update of schedule and all SWOT inputs are attached for your consideration and use to generate your (additional) inputs to the SWOT. Please take a look and provide your feedback by noon Thursday this week, so that I will have a chance to compile all inputs before the conference call (3:30-5:00 Friday). I have a major dental appointment in the morning of Friday, hopefully to extract a lower back molar. Shivers! I thought it appropriate to compile the SWOT ideas in such a way as to make it inclusive, for all to use conveniently at any time. So, questions, comments, suggestions are marked accordingly together with a low level of organization. I hope that the more extended ideas now included will provoke each to email his ideas on topics of interest to him to all. I have left the external opportunities and threats largely alone for now. Thanks again in advance. Martin	
JM 080404: Sorry for not responding sooner, and I may or may not be able to join the call today. The ST has so many advantages, it is only fair to all the other concepts that I point out some additional ST weaknesses ;) 1. "Relative to higher aspect ratio, larger ratio of fast-ion speed to Alfven speed, and larger ratio of fast-ion beta to total beta, potentially exciting Alfven eigenmodes leading to fast-ion redistribution and loss". Redistribution might be useful, but this is yet to be convincingly shown. Loss isn't useful, but has already been observed. Stating the obvious: 2. Little or no room for ohmic transformer in central column at low-A, so fully non-inductive operation is required for long-pulse operation. Finally, I'm also concerned that many of the stated ST advantages are only true in a strongly beam driven system, and may not apply to an ST burning plasma/reactor as presently envisioned. Jon	
MP 080404: Dear STCC,	

Since we did not receive any further input on SWOT since those by DM and AS, I proceeded to add some of my ideas to the ideas and compiled them in the attached file. An appropriate goal for this conf call would be to generate more ideas on SWOT with the attached as starting information.

I also updated the compiled information sent among STCC in the second attached, with blue highlight for the input so far on vision statements. An appropriate goal for this conf call would be to generate additional ideas regarding the vision statements, and if possible, to arrive at some consensus initial draft.

Look forward to the discussion at 3:30 pm. Thanks.

Martin

Attachment: SWOT-DM-AS-MP-080404

Spherical Tokamak SWOT (Dick Majeski, Aaron Sontag, Martin Peng)

1. Strengths (intrinsic):
   - 1.1. Demonstrated operation at high β.
   - 1.2. Near-fully bootstrapped equilibria available.
   - 1.3. Compact size: low capital cost, low tritium inventory.
   - 1.4. High κ.
   - 1.5. Higher κ than standard A tokamak under same level of vertical stability (MP)
   - 1.6. Efficient use of poloidal field coil stored energy (MP): At high k, poloidal field coil current ampere-turn including divertor coils remain comparable to plasma current, compared to being an order of magnitude of the plasma current in standard A designs (e.g., ITER). This is demonstrated in NSTX and MAST.
   - 1.7. Efficient use of TF stored energy (MP): Small gap between plasma and center TF Coil, improving plasma utilization of TF stored energy. This, together with the demonstrated high β, lead to high plasma stored energy over TF stored energy fractions and compact designs. This is calculated in ST-CTF designs so far.
   - 1.8. Ability to create reversed magnetic shear plasmas without requiring hollow plasma current profile (MP): This leads to reduced electron scale instabilities and turbulence (related to the presence of reversed magnetic shear) without increasing tearing mode instabilities (associated with the presence of positive J gradients in minor radius). This is seen in equilibrium calculations of NSTX and MAST reversed magnetic shear plasma modeling.
   - 1.9. Small toroidal moment of inertia (MP): Smaller R resulting in smaller toroidal moment of inertia, allowing large toroidal plasma rotation velocities approaching the ion thermal velocities (Mach numbers approaching 1) under expected level of NBI power, providing strong rotation (ExB) shear and stabilization of ion scale instabilities and turbulence. This is demonstrated in NSTX and MAST.
   - 1.10. Large Alfven Mach number (MP): High local β of the order of unity, resulting in large Alfven Mach numbers of a large fraction of unity, providing strong shearing and stabilization effects on plasma magnetic instabilities including tearing modes and global MHD modes. This is demonstrated in NSTX.
   - 1.11. Suppressed ITG turbulence in the ion ITB region (MP): Under NBI, demonstrated larger ExB shear than nominal ITG growth rates in the confinement zone of the plasma minor radius, leading to strong ion Internal Transport

Barriers (ITBs) in which the ITG turbulence is suppressed sufficiently for the ion thermal diffusivity to approach an irreducible level, which at present is believed to be the neoclassical ion level. This leads to global ion energy confinement times of the order of the ion neoclassical energy confinement times. This is demonstrated in NSTX and MAST, and indicates strongly different physics mechanisms dominating the ion turbulence and transport compared to the likely electron turbulence and transport, as least in ST plasmas and may in fact also be the case in standard A tokamak plasmas.

1.12. Domination of electron turbulence and transport over that of ion (MP): In ion ITB plasmas on NSTX, electron thermal diffusivity dominates over that of ion by a factor of about 4. This dominance is expected to be enhanced in future ST devices as long as ion ITB can be formed in NBI driven ST plasmas so that the overall ion confinement times becomes at least an order of magnitude larger than those for the electrons.

1.13. Small scale up in normalized plasma size (ρ*) from PoP ST experiments to next step ST fusion nuclear science R&D facilities. (MP)

1.14. Over-dense plasmas allowing extensive application of EBW. (MP)

1.15. Small R for increased non-inductive current drive efficiency compared to large R standard A devices. (MP)

1.16. Large toroidally trapped particle fractions to enable large Ohkawa driven current without eliminating Fisch-Bers driven current near the plasma magnetic axis. (MP)

1.17. Other intrinsic beneficial plasma properties, to be added. (MP)

1.18. Growing demonstration of commonality in plasma science covering all major toroidal plasma science topics across the low and normal A. (MP)

1.19. Small external plasma inductance compared to the internal plasma inductance. (MP): This allows the creation of high Ip, low li plasmas without large poloidal magnetic flux (inductance) linked to high plasma current. Small external induction goes a long way for ST. (MP)

1.20. Low magnetic helicity content, allowing coaxial and point helicity injection to create large plasma current. (MP)

1.21. Other solenoid-free startup intrinsic plasma properties to be added. (MP)

1.22. More readily demountable center TF coil leg relative to standard A devices. (MP): This eases modular designs for present and future ST devices.

2. Weaknesses (intrinsic):

2.1. Fusion power/unit volume ~ $B_T^4\beta_T^2$. High β, 4-9× conventional tokamaks or compact stellarators, is <u>required</u> for an attractive reactor. Reliable high β operation not a given, and is not a feature of NHTX or CTF.

2.2. Near-fully bootstrapped operation not shown and difficult to access. Not a feature of CTF or NHTX.

2.3. Many conventional current drive scenarios not operable. Example: probably no window for FWCD between edge absorption at high harmonics and alpha damping at low harmonics.

2.4. Reactor relevant startup not perceived to be demonstrated (but see below).

2.5. Poor electron confinement makes it difficult to realize promise of a compact, inexpensive reactor.

2.6. No superconducting TF (AS)

2.7. No proven method of NTM control (AS)

3. Opportunities (external):

3.1. High β: Explore routes to routine high β operation. RWM coils, fast flowing liquid metals (ed. ⇒<u>behind</u> first wall).

Includes disruption avoidance. 3.2. Sustainment: Explore higher boostrap current equilibria, NBICD, EBWCD. 3.3. Startup: Gun-based helicity injection. Neutron resistant inductive systems (small iron core, mineral-insulated solenoid). ECH/EBW, LH assisted startup. 3.4. Address, not just study, electron confinement. Low recycling regimes. 3.5. Higher toroidal field devices (1-2T). 3.6. Demonstration of fully non-inductive operation (AS) 4. Threats (external): 4.1. Stellarator-based WMDs. 4.2. Lack of a 1 MA U.S. spherical tokamak. Difficulties of program continuation with only a single 1 MA ST worldwide. 4.3. Lack of a high field facility. No ST operates within a factor of two of the toroidal field needed for a reactor (or even for CTF). 4.4. Lack of an attractive ST-based reactor design. 4.5. Poor support for the smaller U.S. STs. 4.6. There are only two smaller U.S. STs to begin with. 4.7. Outside community doesn't believe ST has significant advantage over AT (AS) 4.8. Perception that slow progress on non-inductive operation is indicative of an insurmountable problem (AS)	
AS 080328: Hi Dick, Think your list gives us a great starting point. I would make the following additions: weaknesses: - no superconducting TF - no proven method of NTM control opportunities: - demonstration of fully non-inductive operation threats: - outside community doesn't believe ST has significant advantage over AT - perception that slow progress on non-inductive operation is indicative of an insurmountable problem I'll send a separate email with a draft vision statement soon, so I can just think about basketball this weekend. Aaron	
DM 080321: All: Well, I decided it is important to SWOT first. I'm sure that this is far from complete, but perhaps the attached will stimulate comment. Cheers, Dick	

Attachment:

Spherical Tokamak SWOT (Dick Majeski)

1. Strengths:
   1.1. Demonstrated operation at high β.
   1.2. Near-fully bootstrapped equilibria available.
   1.3. Compact size: low capital cost, low tritium inventory.
   1.4. High κ.
2. Weaknesses:
   2.1. Fusion power/unit volume ~ $B_T^4\beta_T^2$. High β, 4-9× conventional tokamaks or compact stellarators, is required for an attractive reactor. Reliable high β operation not a given, and is not a feature of NHTX or CTF.
   2.2. Near-fully bootstrapped operation not shown and difficult to access. Not a feature of CTF or NHTX.
   2.3. Many conventional current drive scenarios not operable. Example: probably no window for FWCD between edge absorption at high harmonics and alpha damping at low harmonics.
   2.4. Reactor relevant startup not perceived to be demonstrated (but see below).
   2.5. Poor electron confinement makes it difficult to realize promise of a compact, inexpensive reactor.
3. Opportunities:
   3.1. High β: Explore routes to routine high β operation. RWM coils, fast flowing liquid metals (ed. ⇒behind first wall). Includes disruption avoidance.
   3.2. Sustainment: Explore higher boostrap current equilibria, NBICD, EBWCD.
   3.3. Startup: Gun-based helicity injection. Neutron resistant inductive systems (small iron core, mineral-insulated solenoid). ECH/EBW, LH assisted startup.
   3.4. Address, not just study, electron confinement. Low recycling regimes.
   3.5. Higher toroidal field devices (1-2T).
4. Threats:
   4.1. Stellarator-based WMDs.
   4.2. Lack of a 1 MA U.S. spherical tokamak. Difficulties of program continuation with only a single 1 MA ST worldwide.
   4.3. Lack of a high field facility. No ST operates within a factor of two of the toroidal field needed for a reactor (or even for CTF).
   4.4. Lack of an attractive ST-based reactor design.
   4.5. Poor support for the smaller U.S. STs.
   4.6. There are only two smaller U.S. STs to begin with.

MP 080318:
I looked around for information on SWOT to see if this can be appropriately linked to what the STCC has discussed so far regarding the MOC of "Future Design Benefit."

First, here is some relatively straightforward info that may be helpful:

- Strengths: What intrinsic attributes of the ST configuration, relative to other configurations, are helpful,
- Weaknesses: What intrinsic attributes of the ST configuration, relative to other configurations, are harmful,
- Opportunities: What external conditions are helpful, and
- Threats: What external conditions are harmful

to achieving the ST visions, which in turn enable achieving the ST mission?
Also, creative elements of the SWOT would include:

- How can we use or maximize the benefit of each strength?
- How can we correct or minimize the impact of each weakness?
- How can we exploit each opportunity?
- How can we defend against each threat?

A set of working visions for 5, 10, 15 years will made it easier for us to write down the draft answers for these questions.

To relate these to the MOC of "Future Design Benefits", I can see a link using an example topic, such as "utilizing the high ST macroscopic stability margins in beta-T." There of course should be other viable topics.

- A ST strength: ST is intrinsically stable to macroscopic MHD modes on an equivalent basis to Tokamak at about up to 4-8 times the beta-T values (up to 5-10% vs. 40%). By operating at 1/3 to 1/2 of this limit, there is expected an intrinsic benefit of robust macroscopic stability that help avoid disruptions in an ST burning plasma capability (STBPC).
- The related weakness: ST and Tokamak plasmas have substantial finite probability of plasma disruption when beta-T (or related parameters) approaches this limit in continuous operations, without applying active feedback controls of macroscopic MHD instabilities (such as the RWM) and operational controls of plasma profiles. Presently tested active feedback control systems of macroscopic MHD modes are expected to lead to complex and expensive components in ITER design modifications, and likely in future burning plasma applications.
- The related external opportunity: Avoidance of plasma disruptions is also a high-leverage topic for ITER and upcoming S/C long pulse tokamaks such as KStar and JT-60SA. Realistic disruption avoidance approaches for the ST burning plasma capability can be established by establishing a common Tokamak and ST plasma physics knowledge base on this subject.
- The related external threat: Currentless stellarators (such as LHD) have demonstrated at the PoP and PE levels an ability to avoid plasma disruptions without active feedback control of macroscopic MHD modes. Compact stellarators with substantial bootstrap currents (providing up to 50% of the rotational transform) will test its plasma disruptivity at the PoP level in NCSX, which is currently under construction. The anticipated time scale for this test is at present in mid-2010's according to the latest assessment of cost and schedule.
- How to use this strength to benefit the achievement of the ST visions and mission? Can the STBPC be designed with operating beta-T sufficiently below the macroscopic limit to maximize sufficiently the ability to avoid plasma disruptions? This would aim at the level that sufficiently allows high projected duty factor (at an order of magnitude above the anticipated ITER level and higher toward 30%) of operation required to achieve the ST visions and mission.

To answer this question will require answering the following questions that are related to the "Future Design Benefit" of near

term incremental research: - What is the dependence of STBPC disruptivity and disruption impact on reducing beta-T and increasing safety factor, etc.? - What is the incremental research (including modeling and analysis) in ST and Tokamak needed to establish a common plasma physics knowledge base to answer this question to an adequately low level of uncertainty? - What is the dependence of STBPC parameters and operation conditions on reducing beta-T and increasing safety factor, etc.? This will require well defined "Systems Tradeoff Analysis" of the STBPC. - What is the incremental benefits and cost to the STBPC from the incremental research on this topic, in terms of the projected incremental range of achievable duty factor and required size/cost (accounting for the remaining uncertainties in the knowledge base). The answers to these questions will determine - whether this topic should be a "Strategic Objective" due to large incremental benefits/cost; - what the "Strategies" should be to achieve this objective; and - what the "Short-term goals/priorities/initiatives" for 1, 3, 5 years should be to implement the "Strategies." If this makes adequate sense following improvements by pulling the STCC ideas together on this topic, we should start by identifying other potential high leverage topics to go through this logical development. Sorry about the length of the email, due to the "long-hand" text to convey the ideas that may not have been familiar to some members of the STCC. Thanks for your consideration of this line of logic.	
4. Competitive advantage – What are we best at?	
5. Strategic Objectives – What are the key activities we need to perform to achieve our vision?	
6. Strategies – How do we achieve our objectives?	
DM 3/5/08: As far as statements of our vision for the ST are concerned, can we all please recognize that we have been taken out to the	Copied from Visions, since these are specific

woodshed? We can claim to have been unfairly ambushed by NCSX, but the fact is, that it is NSTX, not C-mod or DIII-D, which will be shutdown as a consequence of the NCSX overrun. There are institutional punishment issues here, but if the ST truly were a compelling choice for fusion, then this would not be the case. 5 year vision: Consolidate as much as possible the physics basis for the ST through well-planned use of the remaining NSTX run time. Identify scientific gaps and promising areas for future progress. Move toward enhanced collaborations with MAST, and full utilization of the smaller U.S. ST facilities. 10 year vision: Through international collaborations, Pegasus, LTX, and an upgraded restart of NSTX, or alternatively a completely new facility, fill in the scientific gaps to form a complete picture of a compelling ST-based burning plasma facility. 15 year vision: Construction of the ST-based burning plasma facility. 20 year and beyond: Operations to establish the design basis for an ST-based DEMO.	options of strategy
7. Short-term goals/priorities/initiatives – What are our 1, 3, 5 year goals to achieve our strategic objectives?	
8. Action Items / Plans – Specific plans to implement our goals	
9. Scorecard – Key performance measures to track our progress towards realizing our vision	
10. Financial assessment	