Booklet Code: TM-217

STEP 1. Identify Challenges

Read the Future Scene carefully and generate ideas for challenges, concerns, and possible related problems. Choose the 16 most important challenges and write them in the space provided

1	The FS states that Oliver is adamant that the neurotechnology implanted in his brain is what allows him the opportunity of a normal life, despite the negative consequences such as insomnia. Oliver has become very dependent on the technology, which may have caused him to develop an external locus of control. This is an issue because neurotechnology may be decreasing Oliver's autonomy.
2	Prisha plans to use an EESAA, which are animals genetically designed through a modified cloning process. Many religions have objected to the usage of cloning because they think it is thwarting the work of God. As a result, the EESAAs may raise several religious questions.
3	Nikola's implant, although deactivated, is still connected to her brain tissue. Many brain implants are made of rigid materials that do not move in the skull with the brain. Therefore, if her brain were to move around in her skull, it could cause brain damage- as it might damage the tissue, which is a threat to her neurological health.
4	Military officers have a mandated implant that reduces stress response in the autonomic nervous system. The autonomic nervous system contains the sympathetic nervous system, which controls life-saving fight or flight responses. If the stress response in the nervous system is decreased, then in a life-threatening situation (such as a robbery or potential for a car accident) veterans may not have the proper life-saving reactions, which could put them at risk of harm.
5	Ricardo's therapist is trying to convince him to use a more invasive option: BCIs. Because of this interaction, and the influx of new neurotech users, Ricardo may feel pressured to get the BCIs. As a result, he may end up getting the BCIs while possibly overlooking its safety concerns.
6	The deep brain stimulation utilized in Oliver's case sends electrical impulses that override the limbic system in order to control his emotional responses. However, the limbic system is responsible for a variety of other functions, such as arousal and hunger. If the implant continues to alter the limbic system in Oliver's brain, his levels of hunger and arousal may be disturbed.
7	Prisha is required to participate in a research study on the effects of an EESAA on her life. Hispanics and Asians report the lowest rates of visiting a doctor or provider for mental healthcare. Because of this, not enough people of these ethnicities might not participate in the study because they don't see the value in mental health improvement. Since people of different ethnicities have subtly different medical characteristic, the potential lack of diversity of the study may cause the study to not capture how these races may react to the EESAAs.
8	Experimental treatments such as the EESAA are extremely costly, and national insurance only covers a fraction of the price. Because some people might not be able to afford the EESAA and other treatments, they may not be able to get the healthcare they need, putting them at a disadvantage, as they may have to work through mental illnesses with less treatment. These lines of who can afford the treatment may fall on already existing societal income inequality lines, further exacerbating inequality.
9	Considering the CIN is "known for its cutting edge research," and has provided for the US military, if it were to rise to a position where it "controlled" the neurotech market, the CIN could be able to spread fake information about neurotech to the general population, posing ethical concerns.

10	Oliver has used a DBS device, which is a device that sends signals to his limbic system if an outburst may occur. If the device malfunctions, then certain functions of the limbic system may be damaged.
11	Ricardo's work surveys dictates his productivity and recreational time for optimal productivity. If Ricardo can't control his own leisure time, then he might exhibit a perceived lack of agency. A perceived sense of agency over one's life and choices is one of the most important things for expressing human identity. Therefore, if Ricardo can't control his own leisure then he might experience a lack of identity which could affect his psychological health.
12	Nikola got an implant during her service in the Drone Force, but after she retired there was no way of removing it. If other officers learn about the inability to remove the implant after retirement, then they may not want to get the implant. As a result, they may not be able to participate in defense initiatives as well.
13	In the future scene, it states that Oliver has lost interest in sports, and has become more erratic. Deep brain stimulation often causes changes in personality, which may be occuring in this scenario. This is an issue because significant changes in personality may strain social relationships between individuals.
14	The CIN is not government-based. This may make it hard for them to share their information with other institutions throughout the US. As a result, the development of the neurotechnology field may be slowed, possibly negatively affecting neurotech business opportunities.
15	Users like Prisha are using neurotech therapies to treat mental illness. Because there's a long-lasting societal stigma around treatment for mental illnesses, it may be harder for users like Prisha to access neurotech that could be beneficial to their well-being, causing potential mental health issues.
16	The CIN is offering neurotechnology therapies to users. Due to the complexity of sensory interaction in the brain (a principle where certain senses affect others), the CIN may not be able to accurately stimulate certain brain functions. This may lead to inadequate therapies for users.

STEP 2. Identify the Underlying Problem

Using the challenges listed in Step 1, identify a problem of major importance to the Future Scene situation. Write your Underlying Problem making sure your question clearly explains the action that will be taken and the desired results/goal of that action.

Based on challenge 10, 13, 15, In Seattle, Washington, the CIN has created neurotechnology implants for users like Nikola and Oliver, but they have had unintended consequences such as personality and sleep issues, physical symptoms caused by implants, and the potential for malfunction or hacking. As a result, the future neurological health of CIN users is at risk, threatening the excellent continuation of neurotechnology therapies. How might reduce the unintended consequences of the CIN neurotechnology implants In order to better protect the neurological health of CIN implant users in 2045 and beyond?

STEP 3. Develop Solutions

Generate solution ideas to the Underlying Problem in Step 2. Choose the 16 most effective solutions and write the elaborated ideas in the space provided.

1	Neurotechnologists will implement a new implantable device called a Strentrode. Strentrodes are capable of translating neural activity and stimulating the nervous system from inside a blood vessel, without the need for open brain surgery. They are made from a strong and flexible alloy called nitinol, and are very minimally invasive. This reduces the risks involved with more invasive brain implants, providing a better alternative to deep brain stimulation.
2	The CIN will collaborate with artists to make an initiative that recommends CIN implant users to different creative and artistic opportunities. Creative endeavors like art have been shown to improve mental health. CIN implant users who use these resources for an artistic outlet will have better mental health. This will counteract the unintended consequence of the CIN implants of causing stress levels in users like Nikola. With better mental health, the neurological health of CIN implant users will be better protected.
3	The CIN will collaborate with the UN commission for transnational corporations to establish a group of institutions leading research in neurotech across the globe to localize and make studies uniform. This will mean that the unintended consequences of their neurotech implants are reduced as there's more overall information on the topic, inherently better protecting the neurological health of CIN implant users
4	Neuroradiologists will use iPSC (induced pluripotent stem cells) to grow a custom mini organid of a patient's brain. Stem cells will be genetically modified in vitro to create a model that grows at the normal rate of fetal development. This will allow researchers to test an implant and see the specific way it reacts to a specific patients brain. It will allow researchers to see any potential unintended consequences, such as different neuronal signals being changed by the implant. Early detection of any potential consequences will allow measures to be taken to protect users neurological health.
5	The CIN will modify their implants to be based on optogenetics. Optogenetics is a neurotechnology technique in which genes for light-sensitive proteins are introduced into brain cells. This will allow the CIN to pulse certain lights which can result in certain responses in specific neurons. An unintended consequence of CIN implants are potentially causing unwanted damge to other brain functions, like in Oliver with DBS. Optogenetics will address this unintneded conseuqnece because they can more accurately stimulate neurons, causing less damage to other areas. This wil better protect the neurological health of CIN implant users.
6	The FDA currently has 3 classes for the classification of medical devices, with Class 3 being the most thorough. However, with the extensive research necessary to implement neurotechnology into the lives of citizens, more rigorous research and vetting is needed. Thus, the FDA will create a new Class 4 for neurotechnology. This will reduce unintended consequences of neurotechnology such as implants by requiring more quality assurance in implanatable devices.
7	Neurotechnologists will modify CIN stimulatory implants to limit the intensity of their signals. In the case of hacking or a third-party data breach, this will reduce the amount of data hackers could control and reduce their potential damage. This will reduce the potential unintended consequences of the potential of hacking, which will ensure that the user's neurological health is protected.
8	The CIN will implenent neurodegenerative condition predictive modeling into their implants. Their implants will collect biomarkers from CIN implant users' brains. The CIN will then use these biomarkers as a means to predict the neurodegenrative disorders users will get using AI. By predicting these neurodegenerative conditions, the CIN will have a better picture of what will happen to users in the future. That way, they can better tailor their implants to prevent these conditions rather than cause side effects, which is an unintended consequence. Therefore, the neurological health of CIN implant users will be better protected.

9	The US government will pass a law that regulates the use of neurotech in the military, making it so that they are removable at the end of one's service, requiring ethicality, and more. This way future military members like Nikola have a decreased chance of experiencing unintended consequences from CIN implants, protecting their neurological health.
10	The CIN will create an educational opportunity for CIN implant users. This educational opportunity will teach CIN implant users of the unintended consequences of the implanbts and what users can do about them. For example, with DBS in Oliver, the education will teach users to turn off their device if they begin feeling pain, limiting the unintended consequences of the implant. This will better protect implant users' neurological health.
11	CIN neuroengineers will use cylindrical nerve cuff electrodes for future implants. Because many electrodes and peripheral nerves are prone to migration, this can risk damaging the brain even when inactive, as potentially seen in the case of Nikola, who had physical side effects. Cylindrical nerve cuffs wrap around the outside of the nerve, moving with them, allowing for signals to stay accurate and reducing the unintended consequence of the risk of damage to the brain, protecting users neurological health.
12	Neurologists and researchers of CIN will collaborate with the US military to develop a required program for all members of the military who get implants, once they leave service, they will use this program to reintegrate into society, not only helping them with social relationships, but also reestablishing their fight or flight responses. This will help reduce the unintended consequences, especially in the long term, and as a result, their neurological health will be better protected.
13	CIN's neurotechnologists will filter out the signals their implants track. They will use band-stop filters, such as the notch filter (which filters out signals at 50-60Hz, which is typically powerline signals). This will improve the signal to noise ratio of the implants. With improved signal data, the implants will be able to more accurately treat patients' brain issues. More accurate treatments would mean less unintended conbsequences of the implants, therefore better protecting the neurologicsal health of CIN implant users.
14	The CIN will deliver their implants into users' brains with nanocarriers. By encasing extremely small implants in nanocarriers, users will be able to swallow them as a pill, which will breach the blood-brain barrier. This change in the transportation of the implant will allow the CIN implants to end up in the brain without the unintended consequences involved with open-brain surgery. Without these risks, users' neurological health will be better protected.
15	Many invasive implants use rigid materials, but when the brain shifts in the skull, these rigid materials don't move, causing damage to the brain. To address this unintended consequence, the CIN will make their implants out of flexible threads. These flexible threads will be able to shift in the skull with the brain, decreasing damage. This decreases the unintended consequences of the CIN implants (damage), thus beter protecting users' neurological health.
16	The CIN will add a neurofeedback feature to their CIN implants. Neurofeedback is a technique in which brain waves are tracked, negative activity is identified, and music is played to users to push them toward more calm states. With practice, users will be able to be calm without the help of the implants. An unintended consequence of the implant is being unable to be removed from the brain in cases like Nikola's, which has caused her stress and headaches. The neurofeedback will make CIN implant users calmer, addressing this unintended consequence. By being more calm, users' neurological health will be better.

STEP 4. Generate Criteria

Generate criteria to determine which solution idea does the best job of solving the Underlying Problem and/or addressing the Future Scene situation. Select the 5 most important criteria for measuring solution ideas and write them in the spaces provided.

1	Which solution will most reduce the unintended consequences of the CIN neurotechnology implants?
2	Which solution will best protect the neurological health of CIN implant users?
3	Because brain implants are often at risk of data leaks, which solution will be the least susceptible to a breach of privacy for CIN users?
4	Because it is important for the CIN program to put their patients at the forefront of their research, which solution will most increase the patient-centricity of CIN?
5	Because patients can become dependent on neurological implants developed by CIN, which solution will most increase the autonomy of CIN implant users?

STEP 5. Apply Criteria to Solutions

From the solution ideas written in Step 3, select the 8 ideas with the most potential to solve the Underlying Problem and list them on the grid. Use each criterion to rank the solutions on a scale from 1 (poorest) to 8 (best). The numerical ranking for one important criterion may be doubled.

Rank solutions.

			Criteria
#	**Solution**	**1 2 3 4 5**	**Total**
1	Neurotechnologists will implement a new implantable device called a Strentrode. Strentrodes are capable of translating neural activity and stimulating the nervous system from inside a blood vessel, without the need for open brain surgery. They are made from a strong and flexible alloy called nitinol, and are very minimally invasive. This reduces the risks involved with more invasive brain implants, providing a better alternative to deep brain stimulation.	6 8 3 7 4	28
2	The CIN will collaborate with the UN commission for transnational corporations to establish a group of institutions leading research in neurotech across the globe to localize and make studies uniform. This will mean that the unintended consequences of their neurotech implants are reduced as there's more overall information on the topic, inherently better protecting the neurological health of CIN implant users	4 5 1 4 2	16
3	Neuroradiologists will use iPSC (induced pluripotent stem cells) to grow a custom mini organid of a patient's brain. Stem cells will be genetically modified in vitro to create a model that grows at the normal rate of fetal development. This will allow researchers to test an implant and see the specific way it reacts to a specific patients brain. It will allow researchers to see any potential unintended consequences, such as different neuronal signals being changed by the implant. Early detection of any potential consequences will allow measures to be taken to protect users neurological health.	7 7 6 8 7	35

4	The CIN will create an educational opportunity for CIN implant users. This educational opportunity will teach CIN implant users of the unintended consequences of the implanbts and what users can do about them. For example, with DBS in Oliver, the education will teach users to turn off their device if they begin feeling pain, limiting the unintended consequences of the implant. This will better protect implant users' neurological health.	1 1 4 5 8	19
5	The CIN will modify their implants to be based on optogenetics. Optogenetics is a neurotechnology technique in which genes for light-sensitive proteins are introduced into brain cells. This will allow the CIN to pulse certain lights which can result in certain responses in specific neurons. An unintended consequence of CIN implants are potentially causing unwanted damge to other brain functions, like in Oliver with DBS. Optogenetics will address this unintneded conseuqnece because they can more accurately stimulate neurons, causing less damage to other areas. This wil better protect the neurological health of CIN implant users.	5 6 2 3 3	19
6	The FDA currently has 3 classes for the classification of medical devices, with Class 3 being the most thorough. However, with the extensive research necessary to implement neurotechnology into the lives of citizens, more rigorous research and vetting is needed. Thus, the FDA will create a new Class 4 for neurotechnology. This will reduce unintended consequences of neurotechnology such as implants by requiring more quality assurance in implanatable devices.	8 4 8 2 1	23
7	The CIN will implenent neurodegenerative condition predictive modeling into their implants. Their implants will collect biomarkers from CIN implant users' brains. The CIN will then use these biomarkers as a means to predict the neurodegenrative disorders users will get using AI. By predicting these neurodegenerative conditions, the CIN will have a better picture of what will happen to users in the future. That way, they can better tailor their implants to prevent these conditions rather than cause side effects, which is an unintended consequence. Therefore, the neurological health of CIN implant users will be better protected.	3 3 5 1 6	18
8	Neurotechnologists will modify CIN stimulatory implants to limit the intensity of their signals. In the case of hacking or a third-party data breach, this will reduce the amount of data hackers could control and reduce their potential damage. This will reduce the potential unintended consequences of the potential of hacking, which will ensure that the user's neurological health is protected.	2 2 7 6 5	22

STEP 6. Develop Action Plan

Develop your top-scoring solution idea into an Action Plan. Thoroughly explain how the Underlying Problem is solved, how the plan will be implemented, and how the Future Scene will be affected.

"Greetings, and welcome to the 2045 session of the Cascadia Institute for Neurotechnology. Our researchers have brought to our attention several unintended consequences with our implants, including personality changes, arousal level changes, and even physical pain and a reduced risk response. This is damaging the neurological health of our users and threatening the continuation of our programs. This is why we are thrilled to introduce our partnership with neuroradiologists and genetic engineers to create the mini-brain simulator. Every patient's brain is different, and we don't yet understand the full way our brains interact. We have created the iPSC (induced pluripotent stem cells) mini brain organoid to better understand our patients' brains. There's a simple recipe: We will take human adult cells, and genetically modify them in vitro to become pluripotent cells. These cells can turn into neurons, blood cells or anything needed for development with only a few key proteins. Using a gel that will resemble an embryonic tissue, an incubator at the human body temp., and a motion simulator to mimic blood flow, a mini-brain will develop, resembling the patient's brain. This will allow us to see the exact neural connections and proportions of the individual brain. These minibrains are completely humane because they don't have outside input to develop a consciousness, as all learning is developed through conditioning. Once we have this exact map of the patient's brain, we can test different treatments for side effects. Using the newly developed qubits instead of bits, we will have the computing power to transfer the billions of neuronal connections in the minibrain into a "digital twin" of the user's brain. All sensory input a user would typically be exposed to will be run into the digital twin, and so the neuronal connections can be an exact replica of the person's brain. The implants will then be "added" to the digital twin and we can see exactly how they will work. This will allow us to see any other areas of the brain the implant might be affecting, and any consequences exhibited. We can then reset the simulation, adjust, and try again until we find an electrode configuration that works for each person's brain with minimal side effects. For example, one of our patients, Oliver, has an impact in his limbic system and suffered from arousal changes. A digital twin would be able to see any arousal changes that occured as well, and adjust the implant to only target specific groups of neurons so these changes don't occur. The digital twin could also see what would happen if the implant was deactivated but left in the brain, as in the case of many of our veteran military officers like Nikola, and would be individualized to there specific brain because of the iPSC. This will allow users to know exactly what will happen with the implant, and eliminate unintended consequences by providing a custom model of the users neurological health. This is a patient-centrist way of improving our implants, making them work for every patient, individually. Any questions?" (A bioethicist from Seattle University raises his hand) "Will this still ensure users have autonomy over their actions, this has been a huge unintended consequence?" "Yes, there will be autonomy from the start. The user will be able to know exactly what will happen to their brain as we will have run through all possible outcomes from the simulator. Because we have found reduced unwanted interference, users won't feel like their control is being taken away. On that note, the digital twin uses the top computing power to ensure the device is secure so there can be no security breaches. The iSPC digital twin has found the optimum frequency of signals so that no third party can severely affect a user." (Another representative raises their hand) "This sounds like a lot, how much will this cost?" "Great question, this is surprisingly cheap and quick to implant! Since stem cells grow on their own in the right conditions, little investment is needed from us. And any cost is balanced out by the fact that users don't have to spend additional time seeking treatment for unintended consequences that would have otherwise risked their neurological health. Because the only sensory data being imputed is on a computer, this is completely humane. Stem cells eliminate the need for a human egg to be genetically modified, making the minibrain completely humane." "All in all, the iSPC mini brains will provide an in vitro model of a specific patient's brain, which can then be transferred to a computer to run simulations of a patient's treatment and figure out ways to reduce any unintended consequences such as personality changes and physical pain. Any unavoidable consequences will be completely transparent to the user and the digital twin will find the best way to avoid them. By reducing these unintended consequences, we will protect our users' neurological health in 2045 and beyond. iSPC on me! Thank you for your time! (The audience erupts in applause)

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